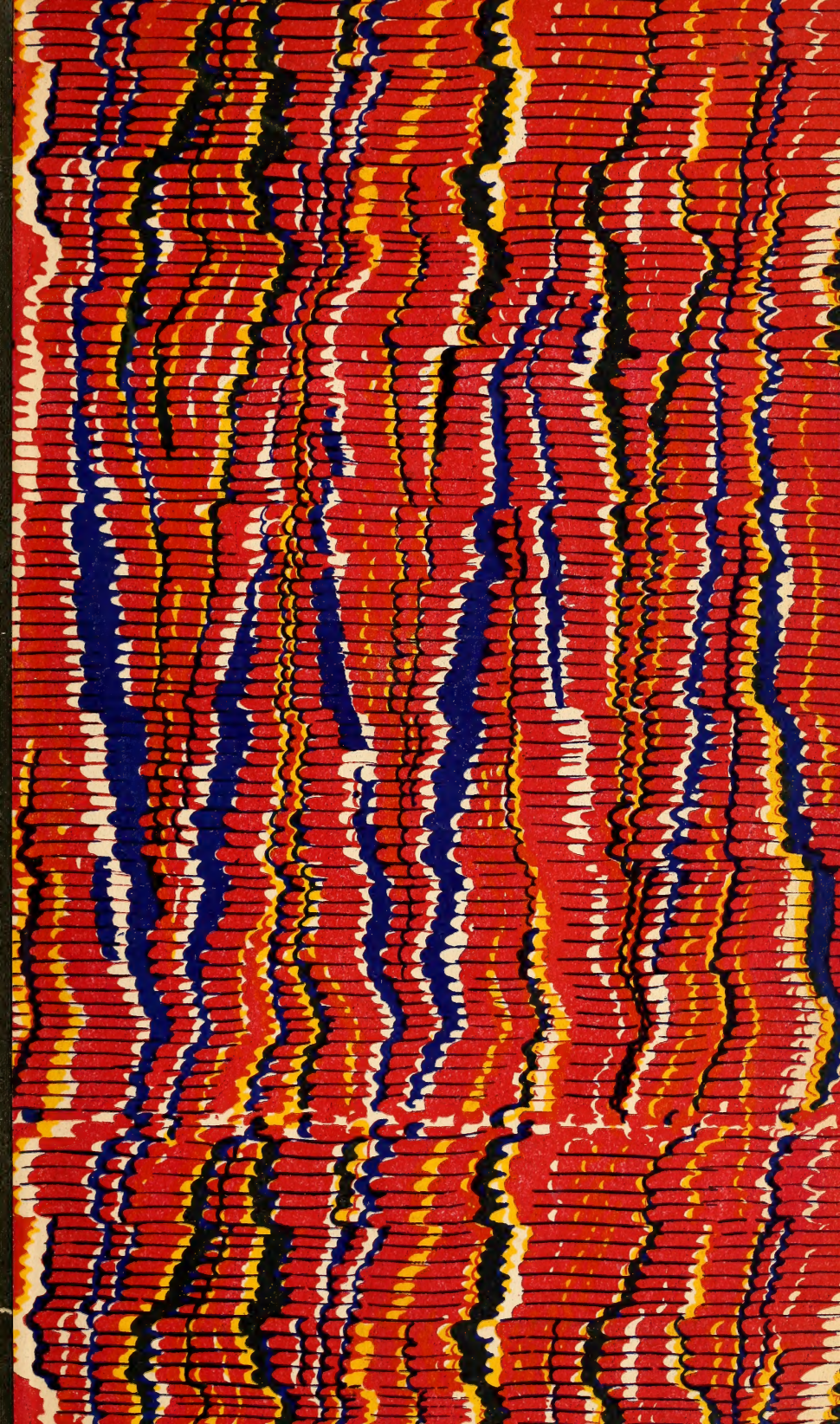


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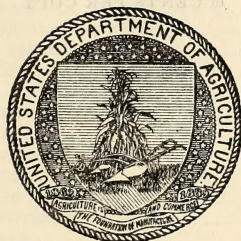
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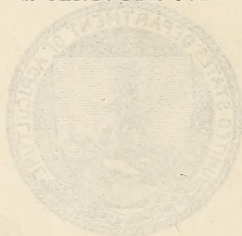
REPORT

OF THE

SECRETARY OF AGRICULTURE

1928

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REPORT OF THE SECRETARY OF AGRICULTURE

PROCUREMENT SECTION
CURRENT SERIAL RECORDS

WASHINGTON, D. C., November 5, 1928.

To the PRESIDENT:

THE YEAR IN AGRICULTURE

Although conditions are never uniform in an agricultural industry as large and varied as that of the United States, the situation this year is perhaps less uneven than in any year since 1920. Certainly there are fewer distress areas. As usual, the situation has bright spots, and spots that are not so bright. Nevertheless, the bright spots predominate. The livestock industries have prospered conspicuously. Substantially larger returns than those of the preceding year will be earned by dairymen, beef producers, and poultrymen. Hog raisers have grounds for optimism. In the early part of 1928 hog prices were unsatisfactory, but the later months brought great improvement. Returns will be smaller, however, from cash grains, hay, tobacco, and potatoes. Present indications are that the gross income of agriculture as a whole will be larger than that of the crop year 1927-28. In all probability this improvement will be reflected in at least a proportionate increase in net income, for the best available evidence indicates that production costs have not been larger than a year ago and may have been somewhat smaller.

As the current marketing season still has some months to run, it is not yet possible to estimate its probable financial results in detail. But it is clear that the year will carry forward the story of recovery from the effects of the postwar depression. This is demonstrated not only by definite assurance of an increased gross income for agriculture, as a whole, but also by numerous signs of progress in an adjustment of farm enterprises to market requirements. Many branches of the agricultural industry have made new gains in the efficiency of production, and likewise in the adjustment of supply to demand. It is beyond question that 1928 will go down in American agricultural history as a year of achievement.

Season's Production Heavy

The season was one of heavy production despite hampering weather conditions in some areas. Yields per acre were about 3 per cent above the average for the last 10 years and about 1.7 per cent above those of last year. Good yields were harvested except in the eastern and central parts of the Cotton Belt, in parts of the eastern Corn Belt, and in an area affected by drought, comprising most of South Dakota, western Nebraska, eastern Colorado, New Mexico, and southern Texas. Sharp changes in temperature in the spring destroyed

the winter wheat seeded on fully 10,000,000 acres and thinned the stand on a large additional acreage. Reseeding was complicated by a cold and wet June. In the late summer and fall the South Atlantic States had torrential rains that set new precipitation records at many stations. These adverse conditions, however, were largely offset by generally favorable harvesting weather in the more important agricultural States, and the upward trend recorded in farm production in the last few years continued.

Acreage of crops harvested was the largest on record, exceeding that of 1927 by 8,000,000 acres, or 2.4 per cent, the increase being larger than that of any year since 1918. It should be recalled, of course, that the area harvested last year was diminished by the Mississippi floods. Expansion of acreage is not always desirable, and the expansion this year in the case of certain crops—notably potatoes—was definitely undesirable. Expansion of acreage, however, is at least a mark of confidence in the future of agriculture. The increase was pretty well distributed throughout the country and was divided among cotton, spring wheat, potatoes, and other leading crops. A decline representing a shift to more intensive crops took place in the acreage previously devoted to hay.

Cotton Acreage Increased

Cotton was planted on about 46,700,000 acres, an increase of 11.4 per cent over the acreage planted last year. As a result, the area in cotton was only 4 per cent below the record acreage of 1926. Losses from the boll weevil, however, were the heaviest since the first few years after that pest spread through the Cotton Belt. Weather conditions were unfavorable for cotton. In consequence the cotton crop in October was estimated at less than 14,000,000 bales, compared with 17,977,000 bales in 1926. Last year's small crop of 12,955,000 bales was held down by acreage reduction, boll-weevil damage, and the Mississippi floods. Although cotton prices now are lower than those prevailing in October, 1927, the market has showed strength recently. Since the production is greater than last year, the outlook for cotton incomes is encouraging.

Our wheat production exceeded 900,000,000 bushels for the first time since 1919. The increase was mostly in hard winter and in durum wheat. Indications are that the world's supply of wheat for the 1928-29 marketing season will be about 5 per cent greater than that of the 1927-28 season. Canada, our most important competitor in wheat, has a record crop, although a part has been reduced in quality by frosts. Europe, outside of Russia, has a crop somewhat larger and of better quality than that of last year. But the increase in the world's supply will be considerably offset by an increase in the demand. In Europe the consumption of wheat will probably be stimulated by its relatively low price, and by the fact that the corn crop in southern Europe is short. Moreover, Russia's rye crop is short, and that country will probably import more wheat than it did in 1927-28. Turkey and northern China have short wheat crops. The prospect is for consumption of this season's large wheat production to an extent that should leave only a comparatively small increase in the carry-over.

Effect of Early Marketing

In the last two months wheat prices in the United States have averaged about 23 per cent lower than those of the corresponding period in 1927. This depression is doubtless to some degree a result of the increase in the world's production of wheat, but the decline was greater than supply and demand conditions seem to justify. It is well known that heavy marketings at the beginning of a season tend to depress prices too much, as was strikingly demonstrated in 1923-24. The present season resembles 1923-24 in its wheat-supply position, and may resemble it also in its wheat-price movements. In 1923-24 wheat prices fell during the early marketing, but advanced as the season progressed. Wheat moved to market in heavy volume during August of this year. The price depression was manifestly attributable in part to a glutted domestic market. Our share in the world's output of wheat does not give us a determining influence on the price of the crop, which depends on total world production. This is shown by the fact that in some years recently big crops in the United States have sold at high prices, whereas in other years small crops have sold at low prices. Yet marketing is important as well as production. This season's experience strongly emphasizes the need of marketing machinery to feed the wheat supply into trade channels as it is required, so that gluts may be avoided and prices kept reasonably stable.

In the long run the final governing influence on prices is the law of supply and demand. Sometimes, however, the market fails correctly to appraise these factors, and it seems of late to have given insufficient importance to the demand side of the equation. The world's demand for wheat has increased at the rate of about 4 per cent a year in recent years. In the 1927-28 season, for example, the world's wheat supply was about the same as it was in 1923-24. Yet the prices of all classes of wheat in the United States were considerably higher. The average price of No. 2 hard red winter wheat at Kansas City in the 1927-28 season was about \$1.41 a bushel, or 36 cents a bushel higher than the average for 1923-24. This is a clear indication that the demand for wheat has increased. Many factors tend to enlarge the world's consumption of wheat, among which the more important are increases in population, recovery in the purchasing power of consumers, and a shift from other bread-stuffs to wheat. These factors will be influential this season.

Utility of Economic Information

Production power, however, tends to run ahead of the increase in consumer requirements, and the adjustment of production plans on the basis of economic information becomes yearly more imperative. As evidence of the use that might be made of this department's economic services I may perhaps draw attention to the statement entitled "Outlook for Winter Wheat," which was issued August 23, 1927. This statement said that "with normal yields in important producing countries the world market situation next year may not be as favorable for marketing our export surplus as it is now." In January, 1928, the spring-wheat growers were advised that "the present indications are that with average or better than average

yields another large world crop of wheat will be harvested in 1928," and that "they should hesitate to increase their acreage." It was further stated that "the outlook for durum is quite unsatisfactory * * * it appears that unless there are crop failures in some of the competing countries even stronger competition may be expected in the next season than in 1927-28." Farmers make far more use of economic information in planning their work than they formerly did, but the practice might be greatly increased with advantage.

Corn Crop Largest Since 1923

Corn production is estimated at about 2,900,000,000 bushels, the largest crop since 1923. In proportion to the number of livestock on farms the output is fairly large and will undoubtedly stimulate livestock production. Corn, which furnishes about half our grain supply, was grown this year on an acreage a little larger than that harvested last year, and the yields, although uneven, averaged a little better. Iowa had a record crop and good yields were raised also in Illinois, Missouri, Kansas, Oklahoma, and Texas. Indiana's crop was about equal to the average of the last 10 years and Wisconsin's crop slightly above the 10-year average. In other important corn-raising States the yields were disappointing. This is a season of abundant feed grains, since oats as well as corn were a plentiful crop, but opportunities exist to feed considerable grain profitably to hogs, cattle, and poultry.

A scarcity of corn and other feedstuffs in Europe has been a factor in maintaining relatively good prices for corn through the past season and is likely to be a factor in the situation for the coming season. The 1927 corn crop of Europe was considerably short of the good crop in 1926. This year's crop is still smaller. Some of the south European countries will have no export surplus and may import some corn to meet their domestic requirements. North Europe will have to depend upon South Africa, Argentina, and the United States for corn.

Argentina's Corn Position

Argentina is our greatest competitor in corn markets, selling not only in Europe but in the port markets of the United States. Production in Argentina amounted to 306,000,000 bushels last year, compared with a pre-war average of 192,000,000. Argentina places nearly all of her corn crop on the market. Of the 306,000,000 bushels she will probably export 250,000,000 bushels. More than 180,000,000 bushels were moved out between April 1 and October 13 of this season. Fortunately Europe took nearly all of this and only a few million bushels have come to the United States. Supplies of old corn remaining in Argentina and South Africa for export during the remainder of this year are no greater and may be less than on the corresponding date of last year, but the new crop in Argentina is being planted under excellent conditions.

Estimates for our buckwheat, rice, and bean crops all show a production less than last year, although sufficient for current needs. Fruit production was heavier than last year but less than in 1926.

Potato production made a record. Possibly 15 per cent of the potato supply will either be utilized as feed for livestock or wasted. Sweet potatoes were a light crop, acreage having been reduced following the excessive production of 1927, and yields held down by unfavorable weather. Other vegetables were grown on an increased acreage but gave rather light yields. Tobacco, planted on an increased acreage, was harvested in rather low yields, so that the crop in weight is not above normal requirements. Considerable differences exist among the various types from the standpoint of quality and stocks on hand.

Exports of Agricultural Products

Exports of agricultural products in the 1927-28 season declined as compared with those of the preceding year. Shipments of pork products, wheat, and cotton dropped by an amount that more than outweighed increased shipments of certain less important export items. In value our agricultural exports for the year were 4 per cent less than those of the preceding year and were the smallest in the last five years. The proportion borne by our agricultural exports to our total exports of all commodities amounted only to 38 per cent. This percentage, with the exception of the figures recorded for 1916 and 1917, is the lowest on record.

Our cotton exports declined 30 per cent in volume, although in value the decline amounted to only about 5 per cent. This is a reflection of the higher price level prevailing in 1927-28. When the season opened foreign cotton-consuming countries, which had bought heavily of our 1926 crop, had considerable stocks on hand, which reduced their import requirements. Takings by Great Britain and Japan, where the textile industries have been seriously depressed, show the greatest reduction. Shipments to continental Europe declined less, and cotton consumption there, particularly in Germany, continued high. Foreign stocks of cotton have now been considerably reduced and the American cotton export outlook is consequently somewhat improved, although the textile industries in many of our leading markets remain depressed.

Our wheat exports declined about 6 per cent as compared with the previous year. The principal factors contributing to this decline were larger bread-grain crops in European importing countries and increased production in Canada and Argentina. On the other hand, the European market for feed grains was better, and our exports of barley and corn increased. Rice shipments to Latin American and European markets increased, although at lower prices, but exports of California rice fell materially. Our exports of flue-cured tobacco increased 14 per cent over those of the preceding year. The United Kingdom and China, our leading markets for this type of tobacco, took substantially larger quantities, and our exports of cigarettes to China increased. American flue-cured tobacco has been put in a favorable position by increased use of cigarettes and by limited foreign production of similar tobacco. But exports of this type were offset by reduced shipments of the darker pipe and chewing tobaccos, which are meeting increased foreign competition.

Apples, the leading item in our fruit exports, were exported in a reduced volume, but encouraging gains were recorded in the exports

of a number of other fruits, including grapefruit, prunes, and raisins. Exports of prunes and raisins were the largest on record and were 48 and 28 per cent, respectively, larger than in the preceding year. Better quality and better packing have put American fruit in a more favorable position in foreign markets. Lower exports of pork products reflected increased competition from the Netherlands, Denmark, and the Irish Free State in the British bacon trade, and also increased hog raising in European countries. Shipments of bacon and ham were considerably smaller. Our lard exports increased 6 per cent in volume but declined slightly in value. Hog production in continental Europe, although smaller this year than last, seems likely to continue more nearly adequate to meet domestic requirements than it was in the years immediately following the war. This fact has an important bearing on the outlook for our export trade in pork products.

GROSS INCOME OF AGRICULTURE

Comparison of this year's expected results with those of other recent years is necessary to place the current situation in its proper historical setting. This comparison will show us where agriculture is moving, as well as where it stands. Latest comprehensive figures available relate to the crop year 1927-28. In that period the gross income of American agriculture from all products amounted to \$12,253,000,000, compared with \$12,127,000,000 in the crop year 1926-27 and \$12,670,000,000 in the crop year 1925-26. The total for 1925-26 was the highest since 1919-20. Agriculture's gross income in 1919-20, in which year the postwar boom reached its peak, was estimated at \$15,700,000,000. It dropped to \$9,200,000,000 in 1921-22, then gradually recovered until 1925-26. From that point it dropped about 4 per cent the following year, and in 1927-28 regained 1 per cent from the previous year's recession. Gross-income figures, though not a measure of agricultural prosperity, indicate trends and therefore have an important place in the financial record.

In the last two years the gross income of agriculture has changed but little, but important fluctuations have taken place in its distribution. In 1926-27, for example, the income from grains, cotton, fruits, and vegetables was materially below that of 1925-26. In 1927-28, grain and cotton growers made considerably better earnings, but returns from hogs, fruits, vegetables, and poultry were relatively low. Regional variations in returns characterize the present year. As I have already noted, increased returns from the livestock industries will be materially offset by reduced returns from certain field crops, though the gross income of agriculture as a whole promises to be larger than last year.

The net income of agriculture, or the balance available to farm operators for their labor, capital, and management after deducting expenses of production, is a complex item difficult to express briefly. It may be said, however, that viewed either from the standpoint of labor income or from the standpoint of investment returns the net income of agriculture, like the gross income, reached its highest point since the postwar depression in 1925-26, fell somewhat in 1926-27, and increased again in 1927-28, though not sufficiently to put it back to the 1925-26 level.

National Responsibility for Farm Welfare

This does not mean that agricultural grievances are insubstantial, nor does it mean that the remedy for these very real difficulties should be left to the free play of economic forces. During the World War, largely because of appeals for increased farm production, agriculture underwent abnormal and unbalanced expansion. The postwar agricultural price depression was brought about by world conditions, for which the chief responsibility rests elsewhere than upon the farmers. The situation from which agriculture is still suffering has complex economic, social, and other roots. For these the Nation can not escape its just share of responsibility in that its officials advocated overwhelming expansion of production during the war. In like manner the Nation must accept its share of responsibility in seeking and applying sound and adequate relief. In short, agriculture is entitled to practical governmental help in rebuilding its fortunes on a firm and permanent foundation. Failure to extend such help not only would stamp the United States as ungrateful for the response of farmers to its appeals but would materially weaken the social and economic fabric of the Nation.

The Price Situation

The price situation has changed in ways important to farmers during the last year. From June, 1927, to June, 1928, the average level of the prices of farm commodities advanced, whereas the average level of the prices of things bought by farmers remained practically unchanged. Much of the rise that took place in farm-commodity prices, however, came after most of the 1927-28 products had been marketed. Farmers therefore did not get the full benefit of the rise. Cotton and cattle contributed to the rise of the farm-commodity price average in the first half of the 1927-28 season. In the second half the greatest contribution was made by hogs and wheat.

As a measure of the purchasing power of farm products the department recently began using for comparisons the retail prices that farmers pay for what they buy instead of the wholesale prices of nonagricultural goods. Farmers, of course, obtain most of their supplies at retail rather than at wholesale, and a retail index is therefore more appropriate as a measure of the exchange value of farm commodities. Moreover, many of the articles included in the wholesale-price index formerly used enter only slightly or not at all into the expenditures of the average farmer. At the present time (September) the new index of retail prices paid by farmers stands at approximately 157, compared with 100 before the war. Prices received by farmers on September 15 were 141 per cent of the pre-war average. These two price levels as of September 15 indicate a relative purchasing power of farm products of 90.

FARM-COMMODITY PURCHASING POWER

It should be noted that the new index numbers do not measure the purchasing power of farmers, but merely that of a fixed quantity of farm products. They show the power of a given amount of agri-

cultural commodities to purchase certain kinds of other goods, compared with pre-war exchange ratios. The index numbers do not measure changes in farm receipts or in farm expenses nor do they take into account variations in the quantities of farm products sold or of goods purchased. Since these factors influence the buying power of the farmer as an individual, their exclusion from the basis for calculating index numbers makes the latter a measure of the exchange value per unit of goods rather than a measure of the buying power of the producers. Unless this is borne in mind, the index-number system may be misinterpreted.

Under the new system the department uses the prices of commodities purchased by farmers for the family living and for operating the farm. Indexes of these prices are constructed with practically the same base period (1910-1914), and as nearly as possible in the same manner, as the index of prices received by farmers for the commodities they sell. The prices paid are weighted by estimates of quantities purchased for the average farm in the period 1920-1925. Thus an attempt is made to measure the purchasing power of farm commodities in terms of the usual things that farmers actually buy. But the list includes only commodities; it does not include certain very important services for which farm income is disbursed, such as payments of interest on mortgages and loans, rents, and railroad fares.

The New as Compared with the Old Index

Measurement of farm-commodity purchasing power on a basis of retail instead of wholesale price comparisons tells a slightly different story from that told by the index numbers previously in use. Retail prices commonly lag behind wholesale prices in readjustment periods. When prices are advancing it is usual for wholesale prices to advance more quickly and more steeply than retail prices. The opposite happens in periods of falling prices. In consequence the new index-number system shows, for the early years of the post-war depression period, a somewhat smaller disparity between the prices of farm products and the prices of other goods than was shown by the old system. On the other hand, when prices are advancing the tendency is for the retail comparison to show less advance than would be shown by the wholesale comparison. For example, in June, 1928, the last month for which the purchasing-power index was compiled by the old method, farm commodities had a relative exchange value of 95 in terms of the wholesale prices of nonagricultural goods. By the new method, using retail prices as the basis for comparisons, the index number computed for June was 93.

The purchasing power attained by farm products at the present time, as already mentioned, is expressed by the index number 90, with 100 representing the base period 1910-1914. Corresponding annual figures, expressing the average farm-commodity purchasing power since 1920, in terms of this mode of reckoning, are 99 for 1920, 75 for 1921, 81 for 1922, 88 for 1923, 87 for 1924, 92 for 1925, 87 for 1926, and 85 for 1927.

Taxes and farm wages, which do not figure in the index number, remain relatively high. Farm taxes are about 250 per cent of the

pre-war level and farm wages 170 per cent of that level. The prices of commodities purchased by farmers for use in production are lower than the prices of commodities entering into the family living, the figures being respectively, about 148 per cent, and about 162 per cent of the pre-war level. Among the items contributing to the high cost of living on the farm are furniture and furnishings at 208 per cent of the pre-war level, clothing at 179 per cent of the pre-war level, and building materials for the home at 171 per cent of the pre-war level. Food prices are about on the same level as commodity prices generally. Some production items are relatively low, notably feed and fertilizer prices. The prices of farm machinery are close to the general price level.

READJUSTMENT IN CAPITAL VALUES

Indexes of prices and purchasing power, however, tell the story of the agricultural situation only in part. They do not indicate the effects of the tremendous readjustment in capital values which agriculture has undergone in recent years. Although the purchasing power of farm commodities increased from 1921 to 1928, farm real-estate values continued to fall. A survey made in March, 1928, showed that farm real-estate values were only 17 per cent above the pre-war level, compared with 57 per cent above that level in 1921. These figures make no allowance for recent changes in the value of the dollar. In terms of a dollar of constant purchasing power farm real-estate values last March for the United States as a whole were about 20 per cent below the position they held 15 years before.

This decline in farm real-estate values has been a more important factor in the depression than may have been recognized, especially in the case of those who purchased land at the high valuations of the boom period. Real estate comprises more than four-fifths of the average farmer's capital investment. It provides the security for most of his borrowings, the assessment basis for most of his taxes, and a depository for his savings. In the first 20 years of the present century increases in land values were the usual form in which farmers accumulated their wealth. It is therefore encouraging to note that the downward movement is slackening. The drop in 1927 was less than in the immediately preceding years, and a tendency toward comparative steadiness appeared in areas where the decline had been especially prolonged and severe. This was the case in Iowa, Montana, and the Dakotas. Average values per acre in Iowa declined less in 1927 than in any year since the beginning of the postwar depression.

Changes in Tenure Status

Readjustment of land values has been accompanied by changes in the tenure status of farmers. As here used the term "tenure status" includes both variations in the percentage of tenants and variations in the farm owner's equity in his farm. From 1921 to 1925 the percentage of tenants in the country increased from 38.1 to 38.6. In this period tenants migrated in such large numbers from most of the old Cotton Belt as to leave much of the poorer land unfarmed. Tenancy increased in the new Cotton Belt, in the West North Central States, and in the mountain divisions. Areas near industrial

centers, on the other hand, showed an increase in owner-operator farmers. This movement was most noticeable in the North Atlantic States, where many influences promote it. Cheap automobiles and good roads solve the transportation problem and the progress of invention makes city conveniences available to farm homes near cities. Moreover, a small land holding may contribute toward living expenses. But the output of such truck-gardening farms adds comparatively little to the Nation's commercial agricultural production. Such evidence as is available indicates that since the census of 1925 tenancy has continued to increase in some regions, and that taking the country as a whole there has been no increase in owner-operator farmers.

Much involuntary farm ownership has resulted from the postwar decline in farm values, and this involuntary ownership has created new problems. Tenant operation pending disposal is not considered wholly satisfactory. Owners report difficulty in getting good tenants and the satisfactory handling of foreclosed properties is often a complex problem. In certain cut-over regions, where postwar commodity prices will not sustain production, much tax delinquency exists.

It is well to bear in mind, however, that the story of land utilization in the United States during the last few years has another aspect. Though in some districts land that perhaps never should have been farmed may eventually go back to grass or timber, in other regions farm acreage has expanded and is still expanding. This is unmistakable evidence that American agriculture is vigorous and progressive, and through efficiency can occasionally turn even a bad economic situation to good account. In southern portions of the Great Plains region the recent expansion of the cultivated area has been notable. This growth, which had its start in war-time needs for increased production, has been sustained by improved mechanical methods in the raising of cotton and grain.

Expansion in Great Plains

While the cultivated area in some other sections has receded, that of the six principal Great Plains States—the Dakotas, Nebraska, Kansas, Oklahoma, and Texas—has increased. The average acreage of the principal crops in these States for the 3-year period, 1925-1927, was more than 8,000,000 acres greater than in the 3-year period, 1919-1921. Texas contributed nearly 5,000,000 acres to this expansion, North Dakota and Nebraska about 1,000,000 acres each, and Kansas, South Dakota, and Oklahoma the remaining million acres. Strong stimulus was exerted by technical progress in cotton growing and in wheat growing by the eastward and northward march of the combined harvester and thresher. Technical progress enabled Montana, part of which is in the Great Plains area, to expand its cultivated area about 1,000,000 acres. Colorado had an expansion of some half a million acres. Minnesota increased its cultivated area by more than 1,000,000 acres. In most of these States the tendency toward acreage expansion was also in evidence in 1928 and seems likely to continue into 1929.

In Texas the expansion in acreage was chiefly in the west and northwest sections, where comparative absence of the boll weevil

stimulated cotton growing. Considerable gains also took place in the acreage devoted to small grains. Throughout the Great Plains the increase in the cultivated area has been largely at the expense of grazing land. Minnesota's expansion can be attributed in part to increased efficiency in crop production and in part to steady growth in the dairy industry. In Wisconsin cultivated acreages showed little change in the 6-year period mentioned. This stability was probably due in part to small increases on the newer farms in the northern portions of that State and in part to the fact that returns from dairying were relatively favorable. In most other States east of the Mississippi River the area in cultivated crops declined.

Significance of Tenancy Trend

In appraising the present situation as to farm-land values, it should not be assumed that the above-noted growth of tenancy is necessarily an unfavorable sign. In many regions productive farm land can be rented more cheaply than it can be owned when terms of cost, including taxes, depreciation, and repairs, are taken into consideration. Ownership has many advantages. Nevertheless, it may be better to be a renter on good land than an owner on poor land for which too much has been paid. After all, the farmer's problem is to lay out his available capital in the most economical and productive manner. It is not by any means always best to invest heavily in land. Many inquiries come to the department from city dwellers and farmers living in areas where land is still relatively high in price as to the desirability of purchasing presumably run-down farms or abandoned land. Bargains can doubtless be obtained by men who know land values. Prospective buyers should bear in mind, however, that not all land obtainable at a low price per acre is truly cheap.

Such figures as are available on recent tenancy changes indicate that many farmers are unwilling to pay too much for the privilege of owning. In the first 20 years of this century farm-land values in certain important Western States rose faster than land incomes. The net rate of return upon the farm real-estate investment declined steadily until it reached a level materially below the prevailing rate of return on such investments as first mortgages. A change has come about in recent years with the decline in farm-land values. At present valuations the return obtainable on an investment in farm land is somewhat more in line with the prevailing rate of return on other investments. Undoubtedly, however, the problem of tenancy is in part a reflection of unwillingness among farm operators to pay interest charges exceeding the returns obtainable on land investments. Those who supply mortgage-investment money may see in the present relationship of land values to current and prospective earning power a promise of an increased margin of safety. Purchasers will find their returns more adequate to meet their capital charges.

COTTON SITUATION AND PROBLEMS

Conditions for cotton growers were not unsatisfactory during the 1927-28 season. In the months of heaviest movement from the farm cotton prices were the best of the year. The average price at the farm in September, 1927, was 22.5 cents a pound. For the entire

season the average price of Middling spot cotton in 10 spot markets was 19.72 cents a pound, compared with 14.4 cents in 1926-27. As finally estimated our total cotton production in 1927 was 12,955,000 500-pound bales, compared with 17,800,000 in 1926. Though 5,000,000 bales smaller, the crop exceeded that of 1926 in value by more than \$325,000,000. Many growers were consequently enabled to overcome the financial handicaps left by the preceding unfortunate season.

Our cotton supply quickly moved into consumption. In the 12 months ended July 31 last the world's consumption of American cotton was about 15,400,000 bales. This was only about 300,000 bales less than the record consumption of the preceding year. Our cotton exports during the year 1927-28, although amounting to only 7,500,000 bales, compared with 10,900,000 bales in 1926-27, represented a value of \$821,000,000. In the preceding season the much larger volume of our cotton exports realized a value estimated at only \$855,000,000. In the first half of the season mill activity was at the highest rate ever recorded, and at the end of the year the world's supply of American cotton was about 2,700,000 bales less than that on hand at the end of the 1926-27 season. On June 30 last the world's carry-over of American-grown cotton was estimated at the modest amount of 5,000,000 bales.

As is usually the case when the supply of cotton is large, the last three years have produced much discussion as to the factors influencing value and price. Although such discussion normally centers around the quality of the cotton in the annual carry-over, it is generally extended to include the quality of the new crop. In the winter of 1926-27 many persons contended that the cotton carry-over was low and inferior in grade and staple length, and that when counted as so many bales in the supply it exerted an unduly depressing influence on prices. Many growers asserted that the country was probably producing cotton averaging lower in both grade and staple value than it did in earlier times, when more attention was paid to cleanliness in harvesting, and the special influences that have since contributed to shorten the average length of the staple had not been set in operation.

Demand for Data as to Quality

It was felt, in short, that the supply of good cotton was probably not as large as a mere enumeration of the number of bales in the carry-over and the crop might indicate. Accordingly a demand arose for better information as to the quality of the cotton supply, and Congress passed legislation (the Mayfield-Jones Act) and provided funds for this purpose. Thus began an important new branch of the department's work, the main object of which is to furnish regular reports as to the supply of cotton, including both the crop and the carry-over in terms of grade, staple length, and tenderability. Substantial benefits to both producers and consumers of cotton should result.

Cotton prices are affected, of course, by the quality as well as by the quantity of the crop. With a given supply, the lower the quality the lower the price; and conversely, the higher the quality, within limits, the higher the price. Heretofore, however, information as

to the quality of the cotton supply has not been generally available, and consequently the principle that quality goods should bring a premium has been overlooked in cotton buying as far as the average farmer is concerned. Growers selling cotton in small lots in country markets often can not get a better price for medium than for very short-staple cotton. Unquestionably, this condition has discouraged the production of good-quality, long-staple cotton. Information obtained under the Mayfield-Jones Act will show cotton buyers and spinners where superior fiber is grown and will tend to bring about a better local price differentiation as to different quality cottons.

In 1927 grade and staple estimates were issued experimentally, covering part of Georgia and another area comprising 6 counties in the southwestern corner of Oklahoma and 21 adjacent counties in Texas. These reports proved of such value and interest that Congress made funds available to extend the work throughout the Cotton Belt. This year all interested persons were enabled to judge market prospects and transact business in cotton on the basis of information concerning the quality as well as the quantity of the supply. The first official canvass of the quality of carry-over cotton was made August 1 and published shortly thereafter. The necessary facts were obtained from owners of cotton, who furnished reports as to the number of bales and the staple length of the cotton in their possession. Information was gathered covering the actual cotton in public and private storage warehouses and compresses, in consuming establishments, on farms, and in transit from merchants to domestic spinners. Data as to the current crop were obtained from gins scattered throughout the cotton States.

Hearty Cooperation Received

In assembling this information the department received the hearty cooperation of growers, spinners, and merchants, and the undertaking aroused wide interest. It drew attention forcibly to the importance of adjusting staple lengths upward in keeping with the demand for better cotton, and promised to exercise a sensible influence in keeping grade differences and staple premiums more strictly in line with the demand for the different grades and staple lengths.

Facts disclosed by the grade and staple reports made in 1927 illustrate the value of the new work. It was found in Georgia that the growers were producing far too much cotton under fifteen-sixteenths of an inch in staple length. No less than 78 per cent of Georgia's cotton production in 1927 was seven-eighths inch or less. On the other hand, the amount of untenderable-length cotton grown in Georgia—namely, cotton thirteen-sixteenths of an inch or less in staple length—proved to be less than $2\frac{1}{2}$ per cent of the State's total production. The survey demonstrated, in short, that Georgia, although producing only a small percentage of actually untenderable-length cotton, nevertheless produces far less cotton of the greater lengths than she might. Evidence was furnished that Georgia, with encouragement in the form of price differentials, could produce cotton from fifteen-sixteenths of an inch to 1 inch in length of staple in most of her counties. Indeed, a fractional percentage of the crop ran from $1\frac{1}{16}$ to $1\frac{1}{4}$ inches in length.

In the Texas-Oklahoma area staple lengths both better and worse than those of Georgia were grown. About 18 per cent of the crop in the Texas-Oklahoma area was thirteen-sixteenths of an inch. On the other hand, only approximately 44 per cent of its output was seven-eighths inch or less, compared with 78 per cent in the Georgia area. The Texas-Oklahoma area surpassed Georgia in the production of $\frac{1}{8}$ -inch cotton. About $25\frac{1}{2}$ per cent of its production was of that length, compared with only $15\frac{1}{2}$ per cent in Georgia. In the grade lengths the Texas-Oklahoma area had a marked superiority. Nearly 11 per cent of its crop was $1\frac{1}{32}$ inch in length of staple, whereas in the Georgia area only 2.64 per cent of the crop attained that length. Of cotton $1\frac{1}{8}$ of an inch and above, the Texas-Oklahoma area had only a slightly better percentage than Georgia. In general the survey showed that the Texas-Oklahoma area is producing short untenderable lengths to a greater extent than Georgia. In both regions it was evident that a larger proportion of cotton 1 inch or more in staple length could be grown. There is a limit to the length of staple that can be profitably grown, determined largely by the fertility of the soil and by the degree to which the variety planted is adapted to its local conditions. In many regions, however, the present tendency is to prefer yield to quality. Longer staples could be produced on numerous farms with no increase in production costs. The problem is to get that combination of yield and staple length which will bring the best net return.

In view of the complaint that American cotton is not meeting the world's demand for good staple lengths as satisfactorily as it formerly did, the evidence furnished by the grade and staple estimates that improvement is possible has obvious importance. These estimates, moreover, should have a beneficial influence in addition to their mere demonstration that more good cotton might be grown. They should facilitate the payment of adequate premiums for superior fiber. Heretofore the practice has been to assemble cotton in even running lots at central points rather than at points of origin. This has entailed the payment of flat prices at country markets, with the result that the grower of superior cotton has been penalized unjustly.

Premiums at Country Markets

Spinners and merchants realize the desirability and justice of reflecting premiums for quality in prices at country markets. With the Cotton Belt adequately mapped from a quality standpoint, growers who produce good cotton will have a better chance to cooperate with neighboring growers in assembling even running lots in commercially significant quantities. Indeed, some of the cooperative organizations have already taken effective steps in this direction. Thus the grade and staple reports should have the doubly salutary effect of indicating opportunities for improvement and facilitating the payment of rewards for improvements accomplished. In the 1927-28 season the premiums paid for the different staple lengths were not as high as they would have been had the supply of staple cotton not accumulated to an appreciable extent from the two preceding years. Normally the premiums paid for superior fiber, if fairly reflected in prices to the individual producers, would consti-

tute a substantial encouragement to the efficient and progressive grower.

Another important departmental activity relating to cotton seeks to promote increased use of the fiber. This object may be attained by extending old and finding new uses for cotton. From the years 1905-6 to 1913-14 the world's consumption of cotton increased annually by a little more than half a million bales. About 240,000 bales of this increase was apparently due to growth of population and the remainder was attributable to increased per capita use of the fiber, either in familiar or in new ways. In the last five years the average increase in the consumption of cotton has been approximately a million bales a year. This exceptionally large gain seems to involve the consumption of approximately three-fourths of a million bales a year in new uses and in the extension of old uses.

Early in 1926 the department concentrated increased attention on the problem of finding additional uses for cotton. Results of preliminary research were published in a report entitled "A Partial List of Uses of American Raw Cotton." Subsequently Congress appropriated funds for expanding this research program and directed the Departments of Agriculture and Commerce to pursue it jointly. A committee composed of members of the Department of Agriculture, members of the Department of Commerce, and representatives of the Cotton Textile Institute (Inc.) was formed to correlate all studies and prevent duplication of work. Under the direction of this committee research is under way in two principal directions: (1) Analysis of the consumption of American cotton by grade and staple, and (2) search for possibilities of enlarging old uses and finding new uses for cotton. This year information was assembled concerning the operation of more than 11,000,000 out of the 34,000,000 active consuming spindles in the United States, and important conclusions have been derived therefrom.

Little Competition in Longer Staples

It has been established that most American mills require cotton better than the average of the grades and staples produced in the United States. Growers have therefore at least a potential opportunity to increase their income by producing cotton of higher spinning value. In the United States and probably throughout the cotton-consuming world the strongest demand is for Middling to Strict Middling cotton from fifteen-sixteenths to $1\frac{1}{16}$ inches in length of staple. Foreign competition in the production of these lengths is practically nonexistent. Clearly, the American cotton industry has here an opportunity which ought not to be neglected.

As already mentioned, our cotton growers produce a large excess of cotton seven-eighths of an inch or less in length. Their output of such cotton is far beyond American mill requirements. In producing excessive quantities of short-staple cotton, United States growers compete with growers of the short cottons of the Orient, and fail to take advantage of their ability to produce the better staples which other countries have not succeeded in growing in important commercial quantities.

Studies of the use of cotton bags in the wholesale grocery trade have disclosed the existence of a large field in which cotton bags might be substituted for jute bags or bagging. Cotton bagging can be made from the lowest grades and staple lengths of American cotton and can be manufactured from high-grade cotton waste. It is true that such bagging ordinarily costs more than jute bagging. In 1926, however, owing to special economic conditions, cotton bagging was cheaper than jute bagging, and cotton could certainly be more often used for bagging.

Many advantages should accrue from increased use of cotton bagging. In the first place, a lighter weight bagging would effect a saving in transportation costs. Then, too, a strong, lightweight cotton bagging of standard construction and weight would help to obviate the practice, much complained of by the American cotton trade, of challenging and taring American cotton in spinners' markets at home and abroad. Moreover, cotton lint does not adhere to cotton bagging as tenaciously as it does to jute bagging.

It should be possible to manufacture a lightweight cotton bagging that could be sold in competition with jute bagging. Four different weights of cotton bagging have been tested in the department's research program. Even the lightest is superior to 2-pound jute bagging and to burlap covering. The use of cotton bagging for cotton must depend largely on its cost as compared with jute bagging. It would probably be necessary also to establish the sale of cotton on the basis of its net weight in all markets, both local and foreign. Settlements made on the basis of gross weights would involve loss if lightweight bagging were used.

Cotton Uses on Farms

Investigation of the present uses of cotton products on the farm showed that 150 articles other than clothing and household furnishings are made of cotton products. More than 100 articles not now made of cotton might, in the opinion of many farmers, be made of that product. Among these suggested new uses for cotton is the use of cotton bags for fertilizer. This alone would afford an outlet annually for approximately 170,000 bales of low-grade cotton. Experiments are under way to determine the practicability of cotton bags as containers for wool.

But the development of new uses for cotton involves economic as well as physical factors. It is not sufficient to decide that cotton might be substituted for other materials in various uses. The question arises, At what price can the substitution be made? In a year of large production and low cotton prices the opportunity to substitute cotton for jute, for example, would be much greater than in a year of low cotton production and high cotton prices. Permanent substitution of cotton for other fabrics is possible only if the increased demand for cotton thus created still leaves a price differential in favor of the use of cotton.

Accordingly, the department is studying price relationships among different bagging materials in order to determine at just what price cotton would have to sell to compete with bags made from other materials. Final results of this investigation will be available shortly and should exercise an important influence on manufacturers'

plans. The first results are now being published in the form of a report on cotton bags and other containers in the wholesale grocery trade. Another report is in preparation relating to the use of bags in the fertilizer industry. It is impossible at this stage to predict how far the competitive use of cotton may be extended, but it can safely be declared that substantial progress in that direction is practicable.

PREMIUMS FOR HIGH-PROTEIN WHEAT

Work similar in principle is going forward in connection with wheat. For several years protein has played an important part in the prices paid for bread wheats and also in the prices paid for certain of the durum wheats. It has not been a price factor to any considerable extent in the case of soft red winter wheat, which is used mostly for pastry, biscuits, crackers, etc. In fact, a high-protein content is not desired in that class of wheat. In the case of the bread wheats, however, high protein commands premiums. Wheat buyers have long distinguished between strong and weak wheats. Strong wheat is characterized by quantity and quality of protein. Not until recent years, however, has the demand for high-protein wheat been sufficient to make protein a definite price factor. To-day the baker demands from the miller flour with a guaranteed quantity of protein. This is made necessary by modern bakery methods whereby the dough is mixed by electric-power machinery. Such methods require a stronger flour than is required by the housewife's methods of hand kneading and mixing.

When the Government released its war-time control over the price and the marketing of wheat, the movement of the crop passed again into the hands of commercial dealers. Thereupon protein became an important market factor. The crops of 1920-1924, inclusive, were marketed with increasing requirements of protein content as a price factor. In this period private and commercial laboratories determined the protein content of considerable wheat. Since 1925 practically all the wheat received at the principal terminal hard-winter and spring-wheat markets in the central West has been tested for protein content, besides being inspected for certification as to its commercial grade. At Kansas City, Minneapolis, Duluth, and Superior laboratories for wheat-protein testing are operated by the State authorities. In States that have no grain-inspection department, official protein tests are made by commercial grain-inspection organizations. Protein testing is also done in several markets by private commercial laboratories. In addition, protein-testing service has been established at points more accessible to the country shipper and to the farmer. This is the case in the central Northwest spring-wheat States and to a more limited extent in the hard-winter wheat territory of the Southwest. Service is given in some places by State institutions and in others by commercial agencies.

Generally speaking, the bread-wheat crops average year in and year out from about 11 to 12.5 per cent protein. Premiums paid for protein vary from year to year, and even within a given crop movement, in accordance with changes in supply and demand. In general it may be said that the amount of premiums paid at any particular time depends not only on the average protein content of the hard

red spring and hard red winter wheat crops, but also on the range of protein within the wheat crop as a whole. Terminal market premiums, however, are not always reflected to the individual grower, except when he ships his own wheat direct to the terminals. This phase of the situation urgently demands a remedy, and the department has studied the problem accordingly.

Protein Problem at Country Points

Many reasons prevent individual growers under present conditions from receiving the full terminal-market value for their high-protein wheat. Lack of understanding on the part of farmers as to what protein is and how it affects prices at terminal markets is quite general. Moreover, neither the farmer nor the country buyer usually knows the protein content of the wheat when it is hauled to the country station. Then, too, facilities are lacking for determining the protein content at the time of its sale at the country points. It would not help greatly if the protein content were known to both buyer and seller, for the country elevator, which is merely the channel through which the producer's grain flows to the terminals, can not be conveniently used by the country-elevator operator for handling and storing separately each individual lot of wheat.

Yet the grower is entitled to the full market value of his wheat. He can to a certain extent influence the protein content of his product. If he selects his seed carefully, properly prepares and cultivates his soil, and uses sound methods of crop rotation, his wheat will have a higher protein content than it would otherwise have. Growers who exercise these precautions should have the cash reward represented by the premium obtainable at terminal markets for high-protein wheat. In short, premiums for protein should be reflected in dollars and cents at country markets to the individual who has the premium wheat. In an effort to bring this about the department held conferences this year with State agricultural colleges in several Wheat Belt States where protein is a factor in marketing and prices. These conferences were attended by wheat growers, country grain buyers, millers, farm-bureau officials, and officials of State departments of agriculture. Intense interest was shown in the problem and the department was assured cooperation in its efforts to find a solution. It is too early as yet to forecast what the outcome of these conferences will be. But the problem does not appear to be insoluble and there is ground for hope that ways and means will be devised in the near future for reflecting more completely protein values in the prices paid to individual growers at country points.

IMPROVEMENT IN LIVESTOCK INDUSTRY

General improvement in the livestock industry, in which all its branches shared, was the most outstanding development in the 1928 agricultural situation. Cattle prices continued the advance which started late in 1926, and by last midsummer reached the highest average level ever recorded in peace time. Hog prices early in the year touched the bottom of a long decline which had started 18 months previously and are now in the upward swing of a new price cycle. Lamb prices were well maintained notwithstanding increased

production. Wool prices were higher. Range conditions generally were fair to good throughout the year; all sections were free from serious droughts. Abundant supplies of corn, hay, and other feed-stuffs were harvested.

In short, the livestock industry is now in the best-balanced condition it has held for many years. Production of cattle, hogs, and sheep has been adjusted more nearly in line with consumer demand for meats at prices assuring reasonable profits to the livestock producers. Total production of meats from inspected slaughter for the calendar year 1928 will probably be slightly larger than in either 1927 or 1926. Total gross income from livestock sales will be larger than last year, and will be almost equal to that of 1926, which was the highest in recent years as a result of that year's high level of hog prices. This year the proportion of the gross income distributed to cattlemen will more nearly equal that going to hog producers. Sheepmen also will receive a larger share.

Prosperity was brought to the livestock industry through readjustments in production, whereby producers reduced their breeding herds and disposed of burdensome surpluses. This readjustment was completed first in the sheep industry about 1922. It was not until 1927 that market supplies of cattle were reduced sufficiently to cause a material rise in the general level of cattle prices. The production cycle of hogs is of much shorter duration than that of cattle and sheep. Hence the swine industry within the last six years has experienced two periods of surplus production and low prices, and one period of small supplies and high prices. It has now entered its second period of reduced production. An upward swing of prices is in progress, which assures hog producers a favorable outlook for the coming year.

Follows Six Years of Depression

Recovery of the cattle industry follows six years of acute depression, during which period cattlemen were forced to liquidate the herds built up during war time. Between January 1, 1918, and January 1, 1928, production was curtailed to such an extent that the number of cattle in the country was reduced by 15,500,000 head, or about 22 per cent. At the present time the number is about the same as in 1913, but the Nation has 23,000,000 more consumers. Reduction in market supplies first developed in the latter half of 1927. Prices responded by advancing sharply. Supplies continued to fall off in 1928, and average prices advanced still higher. In September, 1928, the price level was the highest since 1919. The advance was particularly marked in the prices of the lower-grade cattle. From the standpoint of purchasing power, cattle are at the highest point on record. Margins on cattle feeding this year exceeded all expectations, and the demand for range cattle was never better.

Records of the last 28 years show that under normal business conditions the prosperity of cattlemen in this country varies inversely with the per capita supply of beef available for consumption. A yearly supply in excess of 61 pounds per person tends to depress cattle prices to such levels as to force liquidation. On the other hand, a per capita supply maintained at or below that amount will bring about a rise in prices. In 1926 the per capita supply of beef

amounted to 63.3 pounds. In 1927 it dropped to 58 pounds, and average cattle prices advanced 18 per cent. For the current year the per capita supply will probably not exceed 54 pounds and will be the smallest for any year for which records are available. As a result, average prices of cattle during the first eight months were 27 per cent higher than in 1927 and 44 per cent above those in 1926.

In High Phase of Price Cycle

The cattle industry has a definite cycle averaging from 14 to 16 years. Apparently it is now near the low point of the production cycle and the high point of the price cycle. Previous similar points occurred in 1912 and 1898. It requires three to four years to increase beef supplies through restocking and herd expansion. Since the population of the country is increasing at the rate of more than 1,500,000 annually, the general outlook for the cattle industry is extremely favorable.

The world beef-cattle situation is somewhat similar to that in the United States. Supplies have been reduced and prices are relatively high. The number of cattle in Argentina, the greatest surplus-producing country, has declined materially. Slaughter in Argentine freezing and chilling plants in the first seven months of this year was 14 per cent less than in the corresponding months of 1927. The number of cattle in Australia has also been reduced. Exports from Australia in 1927 were reduced to nearly one-half of the exports of 1926. Exports in the first seven months of 1928 ran a little higher than in the corresponding period of 1927, but the total for the year will probably be less. Decreases in production in Argentina and Australia are partly offset by increases elsewhere. The production of both cattle and hogs has recovered in Europe, and this has had a tendency to reduce the European demand for overseas beef. Canada and New Zealand are increasing their beef production and turning to the United States as an outlet, but the quantities received from these countries are not sufficient to materially affect the market.

Swine producers enjoyed favorable conditions as the year advanced, largely as a result of readjustments effected in production. A high level of hog prices in 1925 and 1926 caused hog producers to expand their output in 1927. When the increased supplies began to reach the market prices started downward. The decline was accelerated by a falling off in both the foreign and the domestic demand for pork products and by an unusually large seasonal movement of hogs to market last winter and last spring. But as soon as these heavy market supplies showed a tendency to fall off prices moved sharply upward. By mid-September the hog-price level was fully 50 per cent above that prevailing early in the year.

Present conditions in the hog industry indicate a very favorable outlook for 1929. The June, 1928, pig survey showed a decrease of about 7 per cent in the spring-pig crop compared with that of 1927 and indicated the probability of a reduction in the fall-pig crop. Thus a smaller supply of hogs for next year's market is practically assured, although average weights will probably be heavier. A larger and more evenly distributed corn crop is expected to lower production costs, and both the foreign and the domestic demand show improvement. This is good evidence that better times are in prospect for hog producers.

Third Largest Hog Slaughter

Inspected slaughter of about 47,800,000 hogs was recorded for the hog-crop year ended October 31, 1928. This was a result of the large increase in the 1927 pig crop over that of 1926. It was the third largest slaughter on record, being 11 per cent larger than that of 1927 and 17 per cent larger than that of 1926, although much smaller than the slaughter in 1923 and 1924. The total market value of the hogs slaughtered under Federal inspection in 1928 will probably be about \$1,000,000,000, or about 6 per cent less than in 1927 and 16 per cent less than in 1926. It is worth pondering that 48,000,000 hogs sold this year for almost \$200,000,000 less than the amount received for 41,000,000 hogs in 1926. Leaders in the hog industry are working on plans for stabilizing production on a more profitable basis and reducing the extent of the periodic price swings.

Hog production is being reduced in some foreign countries, and foreign demand for the hog products of the United States is increasing. The number of hogs in Denmark is 10 per cent less than last year. The number of brood sows in the United Kingdom has been reduced 5 per cent, in Germany 2 per cent, and in the Netherlands 20 per cent. These are the most important foreign producing countries. Foreign demand for hog products from the United States has been weak in the past year, but it is improving. The demand for hog products should be considerably better in the coming year than it has been in the past year. It seems probable, however, that hog production in Europe will be larger in the next decade than during the decade now ending.

Sheep Industry Continues Prosperous

The high degree of prosperity which the sheep industry has enjoyed since 1922 continues. Lamb prices during the first eight months of 1928 averaged higher than at any time since 1925 and have since been fairly well maintained, notwithstanding increased production and larger market supplies. Demand for wool improved during the year. The crop of western-fed lambs was marketed in an orderly manner, which strikingly demonstrated the value of organized marketing. At the beginning of the marketing season the outlook did not promise remunerative returns. Yet in the face of apparently increased supplies prices advanced sharply and were well maintained until the last of the crop had been sold. The strength of the market apparently was due to three factors: (1) Higher pelt values, reflecting higher wool prices; (2) a decrease in the number of lambs fed in the eastern Corn Belt, which more or less offset large increases in the West; (3) orderly marketing of western lambs, which prevented gluts in the eastern cities where lamb prices are largely made.

The sheep industry is on the upward swing of a production cycle. The number of sheep in the country has been expanding since the low point reached in 1922. At the beginning of 1928 the number was 23 per cent larger than at the 1922 low point, and the lamb crop this year showed an increase of 8 per cent over that of 1927. Consumer demand for lamb also has shown a definite upward trend, but has not kept pace with the growth in sheep numbers. So far, however, the increase in production has been well absorbed, owing to an

increasing demand for lambs for flock expansion. During the period of depression in the cattle industry many cattlemen switched to sheep. Now that the cattle industry is again on a profitable basis there may be a tendency to switch back. There is consequently a possibility that the demand for sheep for flock expansion may diminish. Sheep producers would be well advised to give more attention to increasing the demand for their product.

World's Sheep Numbers Increase

The number of sheep in the world is increasing. The number in seven countries, including the United States, New Zealand, the United Kingdom, France, and three other European countries, increased from 125,700,000 in 1927 to 128,300,000 in 1928. Most of this increase was in the United States. In several European countries the upward tendency seemed to have been checked. In Australia the number declined from 104,300,000 to 96,000,000, owing to drought. But with a good lambing season and improved pasture conditions the Australian reduction will be nearly recovered by the end of another year. Sheep are increasing in Argentina and in the Union of South Africa.

Increases in the number of sheep in the United States, Canada, and the United Kingdom have increased wool production, but the gains in these countries are partly offset by decreases in France, Germany, and elsewhere. It is reported that improved range and pasture conditions in Australia are producing more wool from the 96,000,000 sheep in 1928 than from the 104,000,000 in 1927. The world's wool clip outside of Russia and China for 1928 seems likely to be somewhat larger than that for 1927 and about equal to or a little larger than the clip of 1926. The world's demand for wool seems likely to be as good as or better than in 1928.

DAIRY SITUATION FAVORABLE

Generally favorable conditions prevailed this year for the dairy industry. Prices were good and the returns to producers relatively better than those of some other leading farm enterprises. Supplies of roughage and hay were large, and this fact, despite high prices for concentrated feeds, gave dairymen a margin of returns over feed costs as wide as or wider than that of several recent years. Although total milk production was about the same as in 1927, output of cheese, dry milk, and ice cream increased, while that of condensed and evaporated milk and butter decreased. A steady upward trend in the consumption of market milk and cream was recorded, but data are not yet available to show whether this increase sufficed to offset the indicated decrease in the consumption of butter and condensed and evaporated milk.

The consumption of dairy products increases annually. Part of the gain is attributable to the normal growth of population and part to an increase in per capita consumption. Nevertheless, the consumption is not yet up to the level most desirable from a public-health standpoint. Additional increases may be expected from continued effort to improve the quality of dairy products and from educational work to acquaint the public with the reasons for accord-
ing a larger place for dairy products in the diet. As a matter of fact,

there is room for an increase in both the production and the consumption of dairy products in the United States. This country is not entirely self-sufficient in the production of dairy products. For several years it has had an annual import balance equivalent to about 1,000,000,000 pounds of fluid milk, due largely to the importation of certain varieties of cheese from Switzerland, France, and Italy. There has also been a small import balance of butter and dry milk.

Dairy products have brought remunerative prices throughout the entire period of the postwar agricultural depression, and significant regional developments have taken place. Long-distance shipments of fluid milk and cream have affected the demand for cream in areas near large consuming markets. Shipments of sweet cream now appear in the Atlantic seaboard markets from the western North Central States. A notable shift in dairy-producing areas has taken place toward the South, where new creameries, cheese factories, and condensaries have been established. This is in part a result of the fact that market milk commands a price above what can be obtained for milk sold in the form of manufactured products. Such developments, with the changed competitive conditions which they involve, are natural in a progressive and growing industry. In general, the dairy situation remains one of the brightest spots in the agricultural picture.

Foreign Dairy Production

Foreign dairy production appears to be increasing more rapidly than production in the United States, but the recovery of European buying power and increases in our import tariff rates have held imports in check and have maintained prices in the United States above foreign-market prices. Dairy production has developed very rapidly in the Southern Hemisphere in recent years. In the 1927-28 season exports of butter from Australia, New Zealand, and Argentina amounted to 284,000,000 pounds and exports of cheese to 177,000,000 pounds, compared with a pre-war average of 124,000,000 pounds of butter and 57,000,000 pounds of cheese. Conditions are now reported to be favorable for a considerable increase in production over last year. Russia is recovering from the effects of the war. Exports from Siberia now amount to about one-half of the pre-war exports of all Russia, and exports from Baltic countries which have separated from Russia have increased, so that the total exports from Russia and former territory are now equal to pre-war. In the meantime Denmark and the Netherlands continue to expand production. The 1927 butter exports of Denmark amounted to 316,000,000 pounds as compared with a pre-war average of 196,000,000, and the butter exports of the Netherlands amounted to 106,000,000 pounds compared with 75,000,000. The Netherlands has also increased exports of cheese from a pre-war average of 127,000,000 to 205,000,000 pounds.

Fortunately, the economic recovery of Germany has provided an expanding market for these dairy products. The United Kingdom has also continued to buy large quantities. Nevertheless, New Zealand and Denmark continue to ship butter to the United States in the high-price season, and Canadian cheese producers, meeting hard competition from New Zealand and the Netherlands in Europe, are turning to the United States as a market for their products. Switzerland has also been increasing cheese shipments to the United States.

Imports Checked by Tariff

Increases in the tariff rates on butter, cheese, and milk have checked but not stopped imports of dairy products. In 1920 the United States imported 37,000,000 pounds of butter. Following the enactment of the tariff, imports dropped to 7,000,000 in 1922, but this was only a temporary decline, as in 1923 imports amounted to 24,000,000 pounds. The increase in the tariff on butter from 8 to 12 cents per pound, effective March 6, 1926, did not eliminate imports but has held them to about 8,000,000 pounds per year in the past two years. The increase in the import duty on Swiss cheese from 25 to 37½ per cent ad valorem, effective July 8, 1927, had a temporary effect in the checking of imports of cheese from Switzerland, but in the past few months imports have again recovered to about the same level as before the tariff went into effect. Imports of milk and cream from Canada have increased from 2,590,000 gallons in 1919 to 7,479,000 gallons in 1926. Sanitary regulations, effective May 15, 1927, temporarily reduced imports; but a quick recovery from this reduction is to be expected.

IMPROVEMENT IN POULTRY INDUSTRY

The poultry industry has done considerably better this year than it did in 1927. In the fall of 1927 stocks of eggs in storage were heavy and prices low, and poultry also was relatively low in price. Stocks were reduced rapidly as the season advanced, however, and toward the end of the year were small. This year the prices of both poultry and eggs have averaged higher than in 1927, and the outlook for the remainder of the season is for prices at least equal to those of the corresponding period in 1927. Egg production this fall and next winter promises to be no greater and prices should be fairly well maintained.

A trend toward greater specialization, strongly marked in the poultry industry during the last few years, continues, particularly in egg farming. In this branch of the industry the size of the average individual farm is increasing, as well as the number of specialized farms. Accordingly, egg production on specialized farms grows steadily in importance and market influence, though the farm flocks of the Middle West still furnish the bulk of the eggs and poultry entering into commercial channels. Specialization in the poultry industry is promoted by such developments as the recent improvement of the mammoth incubator, the use of coal-stove brooders whereby chick rearing on a large scale at a low cost is possible, the systematic breeding of poultry for increased egg production, the use of electric lights to induce out-of-season laying, and better knowledge of nutrition.

Poultrymen are emphasizing breeding improvement to produce flocks with higher laying capacity and greater freedom from disease. Great possibilities have been opened by methods for rearing chicks closely confined or semiconfined. This system has merits both as a labor saver and as a means of controlling diseases and parasites, and realization of its present promise would introduce profound changes into the poultry industry. Similar methods applied to the raising of turkeys have created hope that the turkey industry

may be reestablished in sections from which it has largely disappeared. Effort to acquaint the public with the food value of poultry and eggs is not as well maintained as it might be with advantage.

FRUIT AND VEGETABLE INDUSTRY

Our fruit and vegetable industry continues to progress in specialization, in the technic and efficiency of production, in the standardization, quality, and pack of its products, and in the breadth of its marketing program. Little has yet been done, however, to stabilize production or to prevent the recurrent glutting of markets. On the Pacific coast fruit production is increasing. It is increasing also in the citrus areas of the South and in many of the best fruit sections in the East. On general farms where fruit is raised as a side line the trend seems to be downward. Fruit consumption per capita is increasing, although the rate of increase is difficult to measure, owing to the rapid change that is taking place in fruit-consumption habits.

The variety offered for sale, coupled with increased per capita purchasing power, has shaken the preferred position of some favorite fruits. Lunch boxes contain fewer apples and more oranges and bananas. Fewer pies are made with dried apples and more with other dried, canned, or cold-pack fruits. Prunes and raisins have gained greatly in popularity. Northern peaches feel the competition of southern peaches, and southern peaches feel the competition of western cantaloupes. Juice grapes encroach upon the market for cider apples. Hawaiian canned pineapples compete with western canned peaches. Oranges and grapefruit have replaced other products. Fresh, dried, and canned fruit has become available in steadily increasing variety and quantity and on a constantly rising level of quality.

Naturally, however, this development has been accompanied by steadily increasing competition among the producers. In areas where crops are irregular or not of the best quality, many growers have been crowded out. Yet the volume of production continues to increase. When high prices for any kind of tree fruit prevail for several years in succession the result is usually a great expansion of the acreage set to young trees. Production continues to expand as the new trees come into bearing and grow larger and may exceed the requirements. Finally correction is brought about, but in a costly and discouraging manner, by the neglect or removal of trees and the bankruptcy of many producers. Partial relief is obtained by a constant struggle for a wider distribution and a continuous effort to improve the quality of the offering. This policy, unquestionably sound and effective as far as it goes, needs, however, to be supplemented by a more far-sighted adjustment of production plans to market needs.

Expansion Effect Is Long Continued

Apple growers still feel the effects of the undue expansion of apple orchards that took place 15 or 20 years ago. Peach production in the Southeast seems to be passing a peak, and unless prices improve the production may decline too rapidly, until the stage is set for

another wave of overplanting. The production of certain fruits in California has exceeded requirements. California growers this year had particular difficulty in marketing clingstone canning peaches, and trouble is expected with grapes. Some relief can doubtless be obtained by skillful marketing, but the really effective remedy, that of curtailing production, is difficult, painful, and time consuming.

Vegetable growers face similar problems. Our national food habits are changing rapidly, and the trend can not be predicted. Shipments of vegetables have been greatly expanded in recent years. Production of asparagus, lettuce, and spinach for shipment has approximately doubled during the last six years, but the production of some of the cheaper vegetables has hardly been maintained. People are spending more money for vegetables, but this is chiefly due to a shift from the old staples to the more costly kinds. If we include potatoes, there is little to indicate that the pounds of vegetables consumed per capita have materially increased.

Improved transportation and the development of new producing areas in the South and the Southwest have extended the season for most kinds and made larger supplies of fresh vegetables available during the winter. On the other hand, fewer cellars are stocked with a winter supply of potatoes, onions, beets, carrots, turnips, etc. Tremendous unmeasured expansion in long-distance shipments of vegetables by motor truck has taken place. The indicated increase in consumption, however, is partly offset by a reduction in the proportion of our population on farms and in rural areas. Moreover, long-distance shipment of vegetables has reduced the relative importance of the market gardens near cities.

Constant Shifts Involved

Shifting of the demand from one season to another and from one vegetable to another entails constant shifts in producing sections. Areas but recently desert or swamp now ship trainloads of produce daily, whereas other areas, left behind in the struggle for the shifting market, have dropped vegetable production and gone back to staple crops. Nevertheless, the output has been maintained close to market requirements, and in years when the acreage is large or the weather exceptionally favorable to production prices are carried below the cost of producing and shipping. Losses thus incurred run into big figures.

Under average weather conditions 3,500,000 acres planted to potatoes will produce about 400,000,000 bushels. This is as large a quantity as can usually be marketed. Greater production is economic waste. This year the potato acreage was expanded about 10 per cent beyond normal requirements. Indications are that the bulk of the excess area, amounting to possible 350,000 acres, will either not be dug or will be dug only to furnish feed for livestock. In this country the value of potatoes as feed for livestock is only about one-fifth of their usual cost of production.

This excessive production was predicted by the Department of Agriculture in January and March. The warning was repeated in May. More confidence on the part of producers in the value of economic data would certainly have kept the production down some-

what. However, such mistakes can not be entirely prevented until more adequate statistical information is available and the forecasting of acreages is a demonstrated possibility. The department hopes eventually to be in a position to keep a careful watch on plantings, both of fruit and vegetables, so that growers may have warning of undue expansion. As in the case of other farm enterprises, the best remedy for maladjustment in fruit and vegetable production is the collection and intelligent use of production statistics.

Necessity of Production Statistics

Economic information becomes more important to the fruit and vegetable industry with each new development in its transportation facilities, and in its technic for preventing the deterioration of perishables. These agencies of progress, as is well known, have enormously extended the distribution area of the fruit and vegetable growers. They have made available the year round such formerly seasonal products as lettuce and celery, citrus and core fruits. Such products are now commercially grown thousands of miles from leading consuming markets. New possibilities have been opened up by the motor truck, which is developing specialized fruit and vegetable areas within overnight hauling distance of market centers. But the growth of the market has been accompanied by corresponding or greater growth in production. If production is to be kept in a satisfactory relationship to market requirements adequate statistics of supply and demand are indispensable. When production outruns consumption the producer suffers materially, but it does not follow that the consumer benefits. Studies made by the department show that overproduction results in ruinously low returns to growers without necessarily affecting retail prices proportionately. Consumers as well as producers would benefit from a better adjustment of supply to demand based on statistical interpretation of market tendencies.

In another part of this report I have mentioned the new produce agency act, which is designed to improve business practice in the fruit and vegetable industry. Another recent law, providing for the standardization of baskets and hampers, promises additional benefit. Advantage should also result from present tendencies toward the better coordination of marketing activities. Within the last few years organizations roughly corresponding to that of the clearing house in the banking industry have been set up in some sections for the purpose of tabulating and exchanging information about shipments and supplies. These organizations, which attempt to deal with the whole industry of a district rather than with the problems of a restricted locality, have found the services of the department very useful. The fruit and vegetable industries are in a state of development and transition. Their present difficulties result from a superabundance rather than from a deficiency of energy and enterprise, and we may confidently expect these difficulties to be overcome.

AGRICULTURAL RELIEF

The betterment of agriculture necessitates a combination of individual efficiency, cooperative enterprise, and wise public policy. Many of the fundamental principles that make for success in industry

and trade can be applied to agriculture. It is necessary to reduce wastes in production and distribution, to expand markets, to find new uses for agricultural products, to organize producers for greater bargaining power, and to invoke Government aid in research and in the maintenance or creation of favorable market conditions. Legislation should be enacted for the control of recurring surpluses of farm products so as to minimize price fluctuations. On this subject I presented my views in detail last year. On this occasion it will suffice to outline them briefly.

The surplus problem is of vital importance not only to agriculture but to the Nation as a whole. It is therefore proper to make the solution of it in some measure a governmental responsibility. This need not involve going further than the Government has gone in aid of other economic interests, although legislation dealing with the agricultural surplus necessarily must be sufficiently different from other legislation to meet the peculiarities of the problem. No law dealing with this question would be entirely adequate at first. Changes in a surplus-control program probably would be necessary in the light of experience. As an initial step it should suffice to create a Federal farm board with adequate authority to finance the handling of surpluses through central stabilization corporations, for which purpose a revolving fund should be provided. Advisory councils responsible to the farmers should be created to assist the board. In this way the surplus problem would, I am convinced, be brought nearer to a solution.

Much can be done for agriculture through indirect Government assistance. Farmers and business men interested in agriculture may cooperate in promoting standardization on the basis of grades and inspection facilities made available through administrative services. Advantage can be taken of the extensive economic data regularly published by the Department of Agriculture. This information is indispensable to a satisfactory adjustment of production to market requirements. Its interpretation and practical application necessitate action by the farmers themselves, individually and through their organizations. The indirect assistance given by the Government to agriculture through its efforts to reflect premiums for quality goods in prices at the farm can scarcely be overestimated. I have already given details concerning work done to encourage the production of high-protein wheat and better staple cotton. In the long run help of permanent value to agriculture will result from just such activities as these, whereby facilities are created for encouraging quality production by cash rewards.

Farmer's Share of Consumer's Dollar

Vigorous efforts should be made to reduce costs and risks in marketing. The prices paid by consumers for farm commodities are in many cases adequate to insure satisfactory returns to the farmer provided high distribution costs can be reduced. In other words, the task is to increase the farmer's share of the consumer's dollar. On this problem much scattered information is available from which I might cite numerous striking examples. I refrain, however, because the whole problem has not been adequately studied, and a just estimate of it can not be made without much more comprehensive infor-

mation than we at present possess. Accordingly, I repeat my previous indorsement of the proposed census of distribution, which should go a long way toward disclosing the weak links in our distribution system and indicating opportunity for specific improvements. Wide spreads between farm prices and consumers' prices are usually the result not of excessive charges by middlemen and others but of excessive service costs. The remedy is not necessarily to eliminate the middleman, but rather to discover means of speeding up and cheapening the distribution process.

RECENT AGRICULTURAL LEGISLATION

In the heat of discussion about general farm-relief legislation we may perhaps fail to appreciate the substantial aid given to agriculture in recent years by the enactment of laws intended to meet various specific requirements. Among the most important of these laws is the cooperative marketing act of July 2, 1926. This measure enables the department to carry on extensive research and other work in the field of marketing. It is not enough to assist the farmer by introducing improved field crops and livestock and by waging war on animal and plant diseases and pests. Assistance must also be given in developing an improved technic of selling and distribution. Under the cooperative marketing act the department is given the authority and the means to encourage farmers' cooperative activities, not by regulation but by research and practical services of various kinds. The scope of this work extends beyond marketing. It also includes effort to eliminate waste in distribution and to effect a better adjustment of production to consumption. Thus it is closely associated with the work done by the department for many years in the grading and standardization of farm products.

In short, the cooperative marketing act authorizes and enables the department to assist the cooperative movement in solving its problems of organization, management, sales policy, financing, and membership relations. As the movement is still in its infancy, the solution of these problems necessitates research as well as education and help in giving effect to principles and methods of demonstrated utility. An important feature of the act permits farmers and farmers' associations to exchange crop and market information directly or through a common agent, an essential practice in efforts to adjust supply to demand. This valuable right was not definitely established prior to the passage of the cooperative act, for the Supreme Court of the United States had decided that certain uses of information by trade associations violated the antitrust law. Under the cooperative law and other legislation of a similar remedial character, cooperative associations are practically exempted from the Federal antitrust laws.

Laws Affecting Collective Bargaining

It may be interesting briefly to mention the steps by which farmers' business organizations have been granted the necessary scope for collective bargaining, because their freedom of action in this respect has often been challenged. To-day there is little room for the applica-

tion of Federal antitrust laws to farmers so long as they do not unduly enhance the prices of the commodities dealt in and do not resort to violence or other unlawful means in the conduct of their business. Cooperative marketing necessarily involves concerted action. It was therefore essential at the outset to protect farmers against the Sherman antitrust law, since that measure is broad enough to apply to cooperative activities that affect interstate or foreign commerce. It denounces every contract, combination, or conspiracy in restraint of interstate or foreign commerce and makes violation of its provisions a misdemeanor punishable by fine or imprisonment. Congress as long ago as June, 1913, undertook to free farmers from the risk of such punishment by declaring that no part of the appropriation for the enforcement of the antitrust laws should be "expended for the prosecution of producers of farm products or associations of farmers who cooperate or organize in an effort to obtain and maintain a fair and reasonable price for their products."

This saving provision was reenacted annually, and in the Clayton antitrust law of October 15, 1914, a section was included dealing specifically with labor organizations and with agricultural and horticultural organizations. This section declared that nothing in the antitrust laws should be construed to forbid the existence and operation of such organizations when instituted for purposes of mutual help, without capital stock and conducted for mutual profit. The Clayton law further provided that neither such organizations nor their members should be held or construed to be illegal combinations or conspiracies in the restraint of trade.

These provisions, however, were not entirely sufficient for the purposes of the cooperative movement, because they involved the restriction that organizations desiring the benefits of the Clayton Act should not have capital stock. Such restrictions made it impossible for cooperative bodies to do business on equal terms with commercial organizations. Accordingly they were removed by the Capper-Volstead Act of February 18, 1922, which gave cooperative associations the right to incorporate and to possess capital stock and also authorized necessary contracts between associations and their members. The Capper-Volstead Act retains the provision that cooperative associations must be conducted for the mutual benefit of their members, and it limits dealing in the products of nonmembers to an amount not greater in value than that of the products handled for members. Associations may restrict each member to one vote regardless of the stock he holds and may limit their dividends to 8 per cent a year. They are required to comply with one of these restrictions and may comply with both.

States Have Cooperative Laws

All but two of the States now have statutes authorizing the formation of cooperative associations. In 28 States these statutes have been upheld by their supreme courts, and contracts made by associations with their members likewise have been declared valid. Moreover, the Supreme Court of the United States has passed on the validity of a State cooperative statute and has held that it does not violate either the State or the Federal Constitution. This important decision

was rendered February 20, 1928, in the case of the Liberty Warehouse Co. *v.* The Burley Tobacco Growers (48 Sup. Ct. Rept. 291). It may therefore be confidently concluded that the cooperative movement is now on a sound legal basis. As already intimated, cooperation must not be employed for the purpose of unduly enhancing the price of agricultural commodities. Under the Capper-Volstead Act the Secretary of Agriculture is authorized to take corrective action when such a practice seems to exist. I have previously observed, however, that agriculture does not lend itself to monopoly practices, and it is very unlikely that cooperative activity will develop antisocial characteristics.

Another important phase of recent cooperative legislation forbids discrimination against farmers' organizations by grain exchanges, boards of trade, and similar institutions. Such discrimination is prohibited in the act of March 4, 1927 (44 Stat. 1423), which declares that no board whose members deal in farm products in interstate commerce shall exclude from its membership privileges any representative of a farmers' cooperative association or group of associations. It is provided that farmers' organizations desiring membership in grain exchanges or boards of trade must have adequate financial responsibility and must agree to comply with the conditions lawfully imposed on other members. An important feature of the act declares that no board of trade may forbid an association represented thereon from making returns to its members on a patronage basis. This act follows a similar provision in the grain futures act of September 21, 1922, applying to terminal grain markets. The United States Supreme Court has pronounced the grain futures act constitutional. The right to return patronage dividends had previously been given to cooperative organizations of livestock producers under the packers and stockyards act of 1921, which act likewise has been upheld by the Supreme Court of the United States.

Agricultural Credit Legislation

Important legislation affecting agricultural credit has been enacted in recent years. A law passed February 8, 1927, amended the agricultural credits act of 1923 by authorizing national agricultural credit corporations to make loans on farm crops being grown for market. Another important piece of recent financial legislation was the act passed February 25, 1927, amending section 24 of the Federal reserve act so as to authorize any national banking association to make loans upon real estate, including farm lands situated within the bank's Federal reserve district, or within a radius of 100 miles of the bank irrespective of district lines. Loans thus made may be for as much as 50 per cent of the value of the land and may run for as long as five years.

Substantial benefits to the fruit and vegetable industry seem likely to accrue from the produce agency act of March 3, 1927. This measure is intended to obviate complaints by farmers against the manner in which commission merchants handling farm produce conduct their business. Such complaints formerly were not infrequent. Returns were often made to farmers indicating that the produce shipped by them proved unsalable due to its low grade or deterioration. Occa-

sionally handling charges were represented as exceeding the sale price of the goods. In the case of egg shipments heavy deductions were sometimes made for breakage. Investigation showed that sometimes the returns were false and that the commission merchant had profited at the expense of the shipper. The produce agency act is intended to obviate such fraudulent practices. It makes it unlawful for a commission merchant receiving perishable farm produce in behalf of another person to destroy, abandon, discard as refuse, or dump the produce without sufficient cause. False reports made with intent to defraud are forbidden, and the Secretary of Agriculture is authorized to provide an inspection service certifying to the condition of the produce upon application by any financially interested person. Inspection certificates thus issued are *prima facie* evidence in the Federal courts of the truth of the statements contained therein.

Many other examples of helpful legislation enacted in recent years could be cited. Those I have given, however, should suffice to show that considerable constructive work has been done by Congress in the interest of agriculture since 1924, the benefits of which will be felt long after the postwar agricultural depression has passed away.

THE TARIFF AND AGRICULTURE

In my report last year and also in 1926 I discussed the relationship of the tariff to agriculture. I pointed out that since agriculture is becoming less and industry more dependent on the foreign market the tendency is for our tariff system to grow relatively more valuable to the farmer than to the manufacturer. It is a gross error to declare, as is often done, that the tariff benefits only the industrial branch of our national business. About one-third of our total agricultural production meets the products of foreign competitors in our own markets. In the calendar year 1924 no less than 45 per cent of our imports of dutiable articles consisted of essentially competitive agricultural products. It need scarcely be emphasized that tariff protection on farm commodities of which we import considerable amounts is valuable to our farmers.

Those who deny the present and prospective value of the tariff to agriculture can not have considered how much of our farm production meets foreign competition within the United States. Vegetable oils, imported as such or extracted from imported oil-bearing materials, afford a good example of this competition. Many of these oils compete directly with certain of our domestic oils and fats, such as lard, butter, and cottonseed oil. The diversity of the oil-bearing materials makes it difficult to estimate the power of this foreign competition. It is significant, however, that a definite tendency toward increased foreign production of vegetable-oil materials has been accompanied in recent years by greatly increased imports of these products into the United States. In 1927, for example, imports of vegetable oil-bearing materials alone, not including substantial imports of extracted oil, totaled almost 1,000,000 tons, an increase of more than 300 per cent over the average imports during the five years immediately preceding the war. Obviously, this is a field in which tariff duties may benefit our producers.

Production of several of our important crops, such as beef, mutton, spring wheat, corn, and dairy products closely approximates our

domestic requirements. Our output of such commodities fluctuates close to the margin between an export and an import basis. Tariff duties on such articles do not necessarily exclude foreign supplies when our own output is insufficient, but before imports begin domestic prices must rise above world prices by the amount of the tariff and the cost of transportation from abroad to our markets. Corn is a good example. In July and August, 1927, the price of corn in Chicago was from 26 to 37 cents a bushel above the price of corn in Buenos Aires. This margin attracted shipments of Argentine corn to United States ports, and in August, 1927, total United States corn imports amounted to 1,176,651 bushels. The duty on corn is 15 cents a bushel. Unquestionably, but for that duty our imports of corn last year would have been much larger.

Dairy Industry Protected

Our dairy industry enjoys effective tariff protection, although its output as a whole practically equals domestic consumption. Estimates of the milk equivalent of the total quantity of milk and milk products consumed in the United States indicate that approximately 1 per cent is imported. Under our tariff the American price of butter is usually higher than in the important foreign dairy markets. It is true that imports narrow the margin when it becomes wide, but only after leaping the tariff barrier. American dairymen, if deprived of tariff protection, would be subject much more frequently to foreign competition in the domestic market. Duty-free imports would enter the United States whenever the difference between American and foreign prices sufficed to cover transportation costs, whereas under present conditions the margin must cover those costs plus the tariff.

Our beef producers enjoy tariff protection, as do producers of spring wheat. Since the war beef production and spring-wheat production have fluctuated between an export and import basis. As our population increases these products probably will tend to rest regularly on an import basis. We usually import 80 per cent of our sugar, 50 to 55 per cent of our wool, 50 per cent of our flaxseed, 40 per cent of our edible nuts, 30 per cent or more of the cattle hides we use, and more than 50 per cent of the calf, sheep, and lamb skins. These commodities are important items in our agricultural business. It would be unwise to deprive the producers of tariff protection merely because some of our farm crops are not yet in position to profit from the tariff. Yet that is practically what would be involved in a campaign for lower tariff duties in the supposed interests of agriculture, because farmers could hardly obtain lower duties on the commodities they purchase without accepting lower duties on the commodities they sell.

Relationship to World Markets

We should recognize that the relationship of our agriculture to world markets to-day is different from what it formerly was. Only 30 years ago about 27 per cent of the total value of our agricultural output entered the export trade as against about 15 per cent during recent years. In the earlier period the farmer had more reason to talk about the small value of the tariff to him, since his commodities,

which were largely exported, had their prices determined, not in the domestic but in the world market. At present, with our agricultural exports decreasing in proportion to our total exports as well as to our total agricultural output, and with imports of agricultural products offering increased competition in the home market, the position of the farmer in respect to the tariff is greatly altered. It would be unwise to forget this fundamental tendency in shaping our tariff structure.

Ultimately we must either balance our domestic structure so that the country will maintain within itself a prosperous agriculture capable of making us self-sufficient in food and fibers or we must follow the way that leads to dependence on foreign food supplies, with our own agriculture relegated to a secondary place in our national life. The second course is not desirable. It is one thing to import commodities which we can not ourselves produce and another to depend on foreign countries for cereals, meats, and dairy products. Tariff protection will tend to prevent that undesirable condition. The United States was formerly the world's chief food-exporting country. That it may one day become dependent on outside sources for agricultural commodities that might be produced at home is suggested by the decline that took place in our farm production per capita of the population between 1897 and 1921. In that period, owing mainly to a retarded increase in our production of wheat, beef, mutton, and wool, our farm output failed to keep pace with the increase in our population. Since 1922 our farm production per capita has increased at a rate exceeding the rate of growth in our population. This condition, however, may be only temporary.

Competition Becoming Keener

Provided technical progress is maintained and our farmers are encouraged with suitable rewards, no apprehension need be felt at present as to our domestic food production. These conditions, however, can not be preserved without forethought. Agricultural competition is becoming more intense throughout the world. Immense new areas have recently been brought into cultivation in Canada, South America, and Australia. These countries, under present conditions, must find their principal market in Europe, where they are already giving our farmers keen competition. It behooves us to see that the battle ground is not transferred to the United States, as it would be transferred by tariff reductions on agricultural products.

Some advocates of tariff reduction in the supposed interests of agriculture believe the result would be to increase our imports of nonagricultural goods. It might rather increase our imports of agricultural goods. Our manufacturing industries seem well able to resist foreign competition, as is shown by their increasing sales in foreign markets. Since the beginning of the century the proportion of manufactured goods entering export trade has more than held its own, despite a fivefold increase in our annual creation of values by manufacturing processes. Agriculture, on the other hand, is losing ground in the foreign market and is moving into a position in which

its chief care will be not to lose ground in the home market as well. In all probability the time is not distant when the home market will be the chief preoccupation of our farmers.

It may be argued, from the fact that our agricultural production has increased greatly in recent years, that American agriculture stands in little need of tariff protection. But the postwar increase in farm output was not a response to satisfactory prices. It was rather the result of war-time stimulation and, to some extent at any rate, of an effort, not entirely logical perhaps, to compensate for low prices by increased production. Certainly the present rate of increase in American farm production will not be maintained indefinitely without better compensation than agriculture has received since the war. Hereafter it will be increasingly evident, I think, that the maintenance of adequate agricultural production in the United States necessitates a tariff policy calculated to maintain the home market for the home producer. The United States, unlike certain other countries, is not in imminent danger of becoming dependent on food imports owing to lack of domestic agricultural resources. Such dependence may conceivably arise, however, if we fail to encourage proper utilization of our resources.

FARM TAXATION LITTLE CHANGED

Little change in farm taxation has taken place in the last year. Fortunately the problem is getting increased attention and a start has been made not only toward greater economy in expenditure but also toward a better adjustment of tax levels for State and local purposes. The drastic upward trend in State and local taxes which was especially marked from 1915 to 1923 has been checked. The recorded increase in farm taxes from 1924 to 1927 amounted to only about $3\frac{1}{2}$ per cent. This evidence of progress may be attributed in part to reassessments on account of the reduced value of farm land, but more particularly to economy, a diminished rate of expansion in public expenditures, and to the tapping of new sources of revenue to supplement the general property tax. Improvement in farm income has made farm taxes less onerous in many sections, but this should not cause a diminution in efforts for greater economy and for improvement in the system of taxation.

The farmer's tax problem is essentially a State and local rather than a Federal problem. Comparatively few farmers are subject to the Federal income tax levy, since personal exemptions have been increased materially in the downward revision of Federal taxes in recent years. Moreover, in States where an inheritance tax is imposed, the deduction up to 80 per cent of the Federal estates tax relieves estates of most of the contribution to the Federal Government that otherwise would be necessary on the death of the owners. Minor Federal excise taxes affecting farmers have been repealed recently, including the automobile tax. Additional relief has come through continued Federal aid for roads and for various agricultural purposes. Such contributions have improved the roads greatly while imposing only a part of the total cost on State and local sources of revenue, and have enhanced the educational opportunities of the rural population.

Notwithstanding tax reductions and subventions by the Federal Government, the crux of the farm-tax problem lies within the sphere of State policy. In recent years the trend in the fiscal policy of the States has been toward securing a greater share of the necessary revenue from sources other than tangible property. Gasoline taxes yielded the States nearly \$259,000,000 in 1927, thus aiding greatly in placing the cost of road construction and maintenance more on those who use the roads and less on the adjacent farm property. Even with the gasoline tax, levies for roads constitute one of the principal burdens on farm real estate.

The Search for New Revenue Sources

It is not easy to discover new and appropriate sources of revenue to supplement existing ones. When new sources are found, care is necessary to prevent the new revenues from becoming mere additions to present expenditures, rather than a means of relief to overburdened taxpayers. The gasoline tax worked so well from its inception that many States soon increased the rate. In some States it has reached 4 or 5 cents a gallon. Although such a rate may not be excessive for the States concerned, it suggests that a tax which serves its purpose exceptionally well may be overworked. Some States are attempting to raise additional revenues by excise taxes on certain commodities of wide use, but not of first necessity. Several are levying income or business taxes of one kind or another. These taxes indicate a desire to reach taxable capacity other than that represented by tangible property such as farm real estate, livestock, implements, etc.

Encouraging effort to improve the prevailing system of State and local taxation has followed a demonstration by farmers, and especially by research agencies, that taxes on agricultural property generally are greater in proportion to income than on other property. As a result many States have given some relief to their poorer agricultural sections by widening the base of taxation for school and road purposes. In States with large industrial and other urban development increased State contributions for schools and roads tend to reduce the tax load on agriculture without handicapping the rural schools. Justification for this may be found in the fact that the importance of every school extends beyond the district in which it is located. This is especially true of rural schools since through migration to the cities many rural pupils become citizens of urban communities.

Research in farm taxation by the Department of Agriculture and by agricultural experiment stations in many States is of comparatively recent origin. Already, however, it has yielded results that have been received with a high degree of favorable public interest, especially on the part of farmers. Effective work also is being done by taxpayers' leagues in the Western States and in some of the Central States, where such organizations investigate and help to control State and local expenditures. The same function might be undertaken with advantage by farm groups, for intelligent scrutiny of public expenditure is necessary to economical use of public funds.

CREDIT FACILITIES OF AGRICULTURE

The availability and cost of credit are of much importance to farmers. In proportion to the output the capital and investment requirements of agriculture are large. Rarely does a farmer on starting to farm have capital enough to pay for his farm, with necessary improvements and equipment. Even after these have been provided the production of crops and livestock requires a substantial investment in capital and labor. Furthermore, the period required for production is mainly fixed by nature and exceeds the production period involved in most other industries. Hence many years of accumulation and saving are necessary before the average farmer can finance his farm plant and his production program without the aid of borrowed capital. Farm-mortgage credit, as well as production and marketing credit, are destined to remain important questions.

The importance of the Federal farm loan system as a source of credit to the farmer is increasing. Net mortgage loans of the Federal and joint-stock land banks outstanding on December 31 increased from \$1,192,235,609 in 1923 to \$1,825,441,964 in 1927, or 53 per cent. Since Federal farm loans constitute one of the cheapest sources of farm-mortgage credit, their rapid increase in proportion to the total volume of credit reduces the average rate of interest on long-term loans. Moreover, their amortization feature distributes the burden of repayment over a long period and lessens total interest payments each year by reducing the principal outstanding. Life-insurance companies are another source of long-term credit offering favorable terms to farmers. Between 1923 and 1927 the farm-mortgage loans of life-insurance companies increased approximately 25 per cent and in 1927 totaled nearly \$2,000,000,000. The department hopes in the near future to show annual changes in the volume and cost of the total farm debt.

Rates of interest on loans by the Federal and joint-stock land banks have declined in recent years. In July, 1925, the rate of the Federal land banks was uniformly $5\frac{1}{2}$ per cent, except in one land-bank district where a $5\frac{1}{4}$ per cent rate prevailed. By July, 1926, 3 of the 12 banks had lowered their charge from $5\frac{1}{2}$ to 5 per cent. In July, 1927, 8 land banks charged 5 per cent, 3 had a rate of $5\frac{1}{4}$ per cent, and 1 had a rate of $5\frac{1}{2}$ per cent. In July, 1928, the rate was 5 per cent in all but the Spokane and Columbia districts, where $5\frac{1}{4}$ per cent was charged. Nearly a score of the joint-stock land banks have reduced their interest rates from the 6 per cent which prevailed in 1924 to $5\frac{1}{4}$ and $5\frac{1}{2}$ per cent. It seems probable, however, that—temporarily, at any rate—somewhat higher interest rates will become necessary on farm-mortgage loans by the land banks. A few of the joint-stock land banks have already announced fractional increases. A probable rise in the rates of the Federal land banks has been indicated in recent statements by some of those banks.

Intermediate Credit Banks

The services rendered to farmers and farmers' cooperative organizations by the Federal intermediate credit banks are of growing importance. Total direct loans and rediscounts of these banks, which

began operations in 1923, increased from approximately \$90,000,000 in 1924 to more than \$142,000,000 in 1927. From 1923 to December 31, 1927, 77 cooperative marketing associations, with a combined membership of more than a million persons, borrowed from them. Their facilities have enabled the cooperative associations to make advances to growers covering a substantial part of the value of their crop. Since their organization the intermediate credit banks also have rediscounted farmers' notes for 615 financial institutions, chiefly agricultural-credit corporations and livestock-loan companies. Livestock-loan companies that rediscount with the intermediate credit banks have been serviceable in meeting the needs of ranchmen who want loans larger than local banks can handle. In the case of loans on dairy cows, notes are sometimes made for 18 or 20 months and are repaid on an amortization plan whereby an agreed amount is deducted monthly from cream checks.

The intermediate credit banks helped to restore confidence in the areas stricken by floods in 1927. Credit corporations with large capital were organized in Arkansas and Mississippi, and the intermediate credit banks stood ready to discount their paper. The knowledge that the resources of these banks were available improved the situation, though the amount of credit actually called for from this source was relatively small.

Early this year the 12 Federal intermediate credit banks were making loans to farmers' cooperative associations at $4\frac{1}{2}$ per cent and were for the most part discounting agricultural-credit paper for local banks and agricultural-credit corporations at the same low rate. Later, when money rates tightened in credit and investments centers, several of the intermediate credit banks found it necessary to increase their interest charges. At this writing two of the banks charge $5\frac{1}{2}$ per cent on discounts of farmers' notes.

Local Banking Difficulties

Many serious farm-credit problems still remain. One such problem arises out of local banking difficulties. In the fiscal year ended June 30, 1927, there were 831 bank failures in the United States, more than three times as many as in 1923 and nearly 50 per cent than in 1926. The increase occurred chiefly in rural districts, reaching a maximum in the last half of 1926. Since then the number of bank failures has shown a marked reduction. Many bank failures may be traced to the period of inflation after the war and the ensuing collapse of prices. The fall in the price of cotton and wheat in 1926 also contributed to the failure of many country banks.

In some parts of the country the problem of merchant credit, discussed at some length in my 1927 report, remains serious. Merchant credit is costly chiefly because of bad bills. Also it tends to discourage thrift, especially where credit is freely granted. The farmer should seek every means of establishing such contacts with banks or credit corporations as will enable him to dispense with merchant credit.

Much has been done in recent years to improve agriculture's credit facilities, but much remains to be done. Research is necessary to determine how our banking and credit structure might be improved, and governmental action, both State and National, is required to

give effect to principles of demonstrated value. Local banking should be improved to give greater stability, to diminish the depositors' risk, and to furnish more stable and dependable service to stronger and better-managed institutions. This is to a large degree a matter of State action.

COOPERATIVE ORGANIZATION OF FARMERS

Cooperative organization among the farmers of the United States, as is well known, has developed greatly in recent years. Naturally its progress has not been uniform. Setbacks as well as advances have been recorded. But there remains a remarkable net gain, the value of which can not be estimated wholly in terms of business done, membership gained, or savings effected. It includes also such important, if not easily measurable, results as a widespread realization among farmers that success in agriculture requires efficient selling as well as efficient production. Hereafter this realization will play an increasing part in the adjustment of output to market requirements, which must play a large part in any rational program for the solution of the surplus problem.

Agricultural cooperation is sometimes charged with responsibilities that do not belong to it. When markets are depressed by overproduction it is difficult even for the most efficient cooperative organization to obtain satisfactory prices. This difficulty is sometimes considered evidence that cooperation does not work. But such an attitude is unjustified. Cooperation can not correct all the basic difficulties of agriculture and is not designed to do so. It may influence the volume of production. But the control of conditions such as exist in the California dried-fruit industry and in the marketing of potatoes this year does not fall directly within the sphere of cooperative responsibilities. The remedy for the surplus problem will necessarily transcend the powers of the cooperative associations. For the present our cooperative organizations must be judged as marketing concerns operating sometimes under favorable, and sometimes under unfavorable, conditions. Cooperative marketing aims to give the farmer an efficient and economical marketing system, while at the same time promoting the adjustment of production to market needs. It emphasizes quality output, and is perhaps the chief influence in the standardization, handling, packing, and processing of farm commodities. It sometimes favorably modifies the purchasing practices of commercial agencies. These and similar activities are the true standards by which cooperative marketing should be judged.

Problems of Cotton Cooperatives

Cooperative organizations must be adapted to varying conditions of production and marketing, and their services and problems vary correspondingly. Cotton cooperatives have exceptional obstacles. Cotton is produced by a large number of scattered farmers whose credit needs often make cooperation difficult. Yet the cooperative marketing of cotton has made considerable progress in the seven years that have elapsed since the first of the present large-scale associations was organized. Probably the most fundamental service rendered, not only to association members but to cotton farmers gen-

erally, is the development of a system of payment for cotton on the basis of its grade and staple. This development, besides modifying dealers' practices, has encouraged the production of better cotton. Savings to their members in interest, storage, and insurance costs have also been effected by the cotton cooperatives. Sales direct to mills, recent plans to centralize sales in regional offices, and economic research carried on for the past two years by the American Cotton Growers Exchange have increased the efficiency of the associations as sales agencies. The establishment of affiliated local gins in some States has provided improved ginning service for members.

After from five to seven years' experience, the cotton-marketing associations are better able than ever before to give their members efficient marketing services. They have contributed to the improvement of marketing conditions and are now prepared to extend and strengthen their services. These associations were obviously on trial during their earlier years. They now appear to have the support of a sufficient number of the growers to assure the permanency of cooperative cotton marketing.

Cooperative organization among grain farmers has been chiefly characterized by the formation of local elevator associations which have corrected local abuses in grain marketing, reduced local handling margins, and improved local services. The organization of State-wide wheat-marketing associations, or wheat pools, has been undertaken, but the quantity of grain handled by such pools has so far been comparatively small. However, they constitute an important experiment in the centralized marketing of grain. Whether such marketing will develop chiefly through extension of the scope of the pooling organizations or through the formation of central organizations by farmers' elevators remains to be seen. Farmer-elevator groups have taken steps to set up terminal-market sales agencies, while the pools are attempting to acquire country as well as terminal facilities and to improve local contracts with their members.

The Livestock Associations

In the cooperative marketing of livestock the most outstanding development has been the formation of cooperative terminal-market agencies. Twenty-five such agencies operated during 1927 in 19 terminal livestock markets. Their business for the year reached the impressive total of \$267,200,000, compared with \$95,969,000 in 1922.

These agencies have greatly strengthened the marketing position of livestock producers. The associations have rendered efficient selling service and made substantial savings in marketing costs for stockmen. The purchase of feeder cattle and lambs and the financing of purchasing and feeding operations are among their services. In addition, they help the producers in dealing with the general problems of the industry. Marketing, legislation, or transportation questions can be handled more adequately when producers are organized. The organizations also influence the supply of livestock and the rate of its movement to market. They help to coordinate production and marketing, and thus to stabilize prices. Livestock shipping associations, by the use of motor trucks, are developing larger units which may serve several communities.

Producers of dairy products have set up and operated some of the most effective cooperative organizations in this country. In the marketing of butter Land o' Lakes Creameries has materially increased the production of high-grade, sweet-cream butter, which is sold under the trade-mark of the cooperative and has created an extensive market for butter of this quality. In 1927 the business of this organization exceeded \$46,000,000. The Challenge Cream and Butter Association, which in 1927 sold 52 per cent of the butter consumed in Los Angeles, has likewise developed a demand for a product of high, uniform quality. Associations marketing milk have made a noteworthy improvement in the handling and marketing of this product. Inspections to improve sanitary conditions in dairies and milk plants, supplemented by continuous laboratory tests of milk delivered by members, have improved and safeguarded the quality and wholesomeness of the product. The associations have increased the consumption of milk by advertising and educational campaigns and by insisting on quality production.

Handling Milk Surpluses

Milk-marketing associations have made notable progress in the control and handling of surpluses. Their price policies have tended to maintain a level of price which is profitable to the efficient dairyman, but which does not encourage expansion within the market area or the shipment of milk from distant regions. Seasonal surpluses are reduced by methods of payment that encourage increased production during the fall and in general tend to uniform production throughout the year. Production thus stabilized results in stabilized, profitable prices. This service can be performed only by producers' organizations, because the voluntary informed cooperation of the producer is necessary to carry out any program looking toward adjustment of production.

Cooperative marketing of fruits and vegetables has been distinguished by the development of a large number of local associations, which render important local services. In many sections, however, the coordination of selling and other functions by the development of federations or a similar type of central organization is necessary. A number of large-scale associations marketing fruits and vegetables are nationally known for their success in this field. These organizations have improved handling practices and standardized grades, and where they control a major percentage of the crop have improved distribution materially. The California Fruit Growers Exchange has improved methods of selling and distributing California citrus fruit and has increased consumption by advertising and by service to retail dealers and also through special merchandizing devices, such as the manufacture and sale at cost of an electrically driven juice extractor for the use of soda fountains. In July last, 46,000 such extractors were in use, each having an estimated consuming capacity of 50 boxes of citrus fruits a year. The work of the Florida Citrus Exchange, the American Cranberry Exchange, and several other organizations of the same type indicates that material progress is being made. No spectacular developments have taken place recently in the cooperative marketing of fruits and vegetables, but the associations concerned have made steady progress. Their leaders

are giving thought to the consolidation of existing organizations through the formation of overhead sales agencies, particularly for commodities not now handled by large-scale cooperatives.

Unnecessary Costs Eliminated

The growth of large cooperative-marketing associations tends to eliminate unnecessary agencies and facilities, whose maintenance adds to the marketing costs that the farmer must pay. Savings which corporations seek through consolidation are obtained, in part, for agriculture by the centralization of handling and marketing in large-scale cooperatives. Cooperative associations handle and market the products of their members at cost. Thus all savings effected go to the producers. Moreover, in regions where strong cooperatives are active, marketing services are performed better and at comparatively less expense than formerly, as a result in part of the influence of the cooperatives on the charges and services of privately owned agencies.

An idea of the present status of large-scale cooperative marketing in the United States can be gained from the fact that more than 150 farmers' marketing associations each transact an annual business exceeding \$1,000,000. Five or six associations have an annual business approximating \$50,000,000 each. Two have passed the \$80,000,000 mark. This development of large-scale cooperative business appears, when we recall that only about one-third of our farmers are members of cooperative associations, as a very striking proof that magnitude of operations may be as profitable for agriculture as for other businesses. As a group our large cooperative associations do a conspicuously efficient job.

One of the most significant recent developments in agricultural cooperation is the attention given by the cooperatives to research. Twenty or more cooperative associations have research departments which assemble data on which to base price and sales policies. The use of crop and market information by these organizations is placing them in the forefront among merchandising concerns. Knowledge gained by research has frequently demonstrated the advisability of centralized action. As a result many local associations, while retaining control of local functions, have turned selling and distribution over to central agencies. Recently, for example, most of the state-wide cotton-marketing associations placed the sale of their cotton in the hands of regional officers of the American Cotton Growers' Exchange. Economic studies have given impetus also to further coordination of the activities of the livestock, dairy, and poultry handling cooperatives.

Suspension of Operations

A few large organizations have been forced to suspend operations in recent years. Several others have been more or less disorganized by low prices for the products they handle. In the last two years five large-scale tobacco-marketing associations have ceased business. The principal reasons for their failure include overproduction, changes in the demand for certain types of tobacco, mistakes in management, and the failure or inability of members to support their organizations. These failures, however, do not justify discourage-

ment about cooperative marketing in general, or even about the cooperative marketing of tobacco.

The experiments in question have taught some important lessons. Growers have learned much about the marketing of their products and about the relation of supply and quality to prices. Moreover, the price policies followed by the tobacco associations, though perhaps unwise from the standpoint of the continuance of the cooperative concerns, probably increased returns to their members for two or three years. Nonmembers also benefited. The brief existence of these associations has left a nucleus of growers who understand and appreciate cooperative marketing.

Cooperative buying of supplies by farmers has become an important part of the cooperative movement. In the East associations for the purchase of dairy feed, seeds, fertilizers, and other bulk supplies are well established. The Cooperative Grange League Federation Exchange, Ithaca, N. Y., and the Eastern States Farmers' Exchange, Springfield, Mass., each purchased approximately \$10,000,000 worth of supplies for their members in 1927. Their activities have resulted in substantial savings to their members, and what is equally important have given them goods of known, standard quality. Cooperative purchase of bulk supplies by marketing associations has been for many years an important feature of their services. Fertilizer, feed, seeds, fuel, and fencing are some of the items purchased extensively by marketing associations. Approximately 50 per cent of all such associations reporting to the department in 1925 stated that they bought supplies for their members.

Another type of cooperative purchasing is that carried on by subsidiaries of large marketing associations. Organizations of this kind are engaged principally in the purchase of marketing and processing supplies, such as containers and machinery. They also buy farm supplies for members of the associations with which they are affiliated.

THE HUMAN FACTOR IN AGRICULTURE

In discussing agricultural problems it is not enough to consider products, values, and profits. The human element—the men, women, and children on the farm—must also be taken into the reckoning. The human factor in agriculture is too often thought of as uniform and unchanging. In reality it is extremely variable and its characteristics are less known than those relating to land, field crops, and livestock. In recent years the public mind has been disquieted, and rightly so, by a rapid decrease in our farm population. Though the postwar loss of population from the country to the towns and cities should not be considered as wholly the result of unfavorable farm conditions, it is unquestionably due to that cause in some degree. It is therefore encouraging to note that the rate of movement is declining. In this, as in other important phases of agriculture, an approach to greater stability can be discerned.

Estimates based on surveys started in 1922 indicate that since that year a gross movement of persons leaving farms for urban centers has taken place to the number of 2,000,000 a year. Simultaneously an opposite movement of population to the farm has taken place amounting to from 1,000,000 to 1,400,000 persons a year. In other

words, the net annual loss of farm population has ranged from 1,000,000 to 600,000 persons. Increase of births over deaths has partly counteracted the downward tendency. Nevertheless there remains an estimated absolute annual loss ranging from 650,000 to 200,000 persons. Our total net loss of farm population between the census enumeration of 1920 and that of 1925 was 2,000,000 persons; the estimated loss from 1925 to January 1, 1928, was 1,283,000 persons. In eight years, therefore, the farm population has diminished 3,283,000 persons, or an average of 400,000 a year.

But in 1927 the situation changed materially. That year saw a smaller gross movement of population away from the farms and a larger gross movement to the farms, so that the net loss was only 192,000, the smallest of any year in the period under review. The exodus was losing momentum rapidly. Some relative loss of population from the country to the town is apparently a normal characteristic of our agriculture by reason of the comparatively high natural rate of increase in the country and because of the progressive substitution of mechanical power for man power. A readjustment of farm personnel to a diminishing labor requirement need give us no concern. It is an evidence of health and progress rather than of deterioration in agriculture. Continuance of present tendencies in the movement of farm population may bring us within a few years to a point at which the annual loss will not exceed the proportion necessary to allow for draining off the excess in natural increase and for the drop in labor requirements.

Persons Leaving the Farms

In the flow of population away from the farms we can distinguish a stream of young adults just ready to enter various occupations, a considerable number of older persons seeking better earnings or jobs more interesting to them than farming, a fair sprinkling of prosperous adults desiring the comforts of urban life, and a group forced to leave agriculture through the disabilities of age. This normal movement involves a perpetual turnover of agricultural personnel, and in periods of agricultural difficulty its volume may be considerably increased. Young people leave the farms for a twofold reason: (1) More children are born and reared on farms than can find a suitable place in farming. The census of 1920 showed that 4,000,000 more persons under 21 years of age were living on farms than there were in any urban group of our population equal in size to the farm group. When we bear in mind the constantly increasing power of agriculture to produce more food and fibers with a given amount of labor, it is obvious that this excess of young people on the farms must be drawn away. (2) Many young people born on farms do not take to farm life. It is natural for such persons to seek other occupations and the fact is not necessarily evidence that farming is without attractions for those adapted to it. American farm people have always been more mobile than those of some other nations, although it is true that some of them are not mobile enough and cling to farm life under unsatisfactory conditions. The normal movement of adolescents away from the farm is quite compatible with the well-being, both of agriculture and of the Nation.

Remedy Not Identical for All

Naturally in a country of such diverse resources, corresponding diversity exists in farm living standards. Farmers occupying extremely small or poor farms need certain assistance that farmers on rich, large farms do not need. The problem of the latter group is not so much how to increase production, or even how to decrease costs, as it is how to cope with economic conditions that too often deprive them of due reward for their efforts. In the first group the problem mainly involves farm organization and management and the size of farms. In the second it is primarily a question of adjusting production to market requirements and effecting economies in distribution and selling. The distinction, in other words, is between farms lacking and farms possessing facilities for doing efficient work.

These differences in basic farming conditions naturally have their counterpart in differences in living standards. City dwellers often think of the farmer and talk of farm life as if there were only one type of farmer and one type of farming. The truth is, of course, that farm conditions vary in all parts of the country to such a degree that no single formula can be invented for the solution of all farm problems. Measures taken for the relief of agriculture must reckon with differences of farming technic in various sections, and differences in the human factor engaged in agriculture. In one district the chief need may be further scientific research; in another it may be more important for the moment to encourage a more general application of well-established scientific practice. Though all farmers may profit by improving their technic, the opportunity for progress in that direction is greater in some localities than in others. In like manner the opportunity to benefit agriculture by improvements in marketing is greater for some regions and for some crops than for others. If we forget these facts and fall into the habit of lumping all farm difficulties together under the general name of the "farm problem," we shall waste much time in discovering the true path of progress.

Rural Governmental Institutions

More attention might perhaps be given to the improvement of rural governmental institutions. In our pioneer epoch the American farm dwelling came inevitably to be situated not in a village but on the farm. American farm homes, except in some localities in New England and in parts of the West, are scattered. Under such conditions adequate governmental organization does not easily spring up. Distances between farms tend to prevent the formation of governmental units capable of undertaking all the usual functions of local collective welfare. The tendency instead, when the need arises for a particular institution, such as a school, a road, or a court district, is to create an organization to discharge that one function. In recent years rural governmental organization has become more complex and comprehensive. Farmers are still handicapped, however, by inadequate civic institutions, and it might sometimes be possible to remedy the trouble by establishing alliances between rural institutions and the urban centers that serve farm needs.

Some few farmers, of course, live within the corporate limits of cities and share their advantages. Others live so close to cities that they can use the church, school, library, and other urban facilities almost as freely as if they dwelt within the city limits. It is estimated that about 8,000,000 of our farm population live within 5 miles of cities having a population of more than 2,500. Approximately 20,000,000 other farm people, however, do not live near cities. These people maintain trade and social contacts with some 13,000 corporate villages ranging in population from 100 to 2,500 and with some 26,000 smaller villages or hamlets not incorporated. Though automobiles and good roads have lessened the farmer's isolation they have not abolished it. Hence many farmers are without good hospital, library, and school facilities. It would seem that public bodies might do something toward making better provision for these wants.

But the improvement of rural life is not wholly, and perhaps not even largely, a governmental problem. Much can be done by making various modern appliances more easily available in the farm home and better adapted to it. The farmer's house is often too far from other houses to admit of city methods of bringing to the farm family the convenience of running water, gas for cooking, electricity for light and power, and sewers. Kitchen facilities, heating plants, lighting equipment, sewage-disposal facilities, etc., must be produced in a form especially adapted for farm use. In this field the inventor and the manufacturer must come to the farmer's aid. The market is waiting for the industrial pioneer.

Census Figures on Farm-Home Equipment

Only a comparatively small percentage of our more fortunately situated farm homes are well equipped with modern appliances. The last census reported that 10 per cent of our farms had water piped in; 7 per cent had gas or electric lighting; approximately 38 per cent had telephones. In certain favored situations the percentage ran higher. In New England, for example, 48 per cent of the farms had water piped in, and nearly 25 per cent enjoyed the same advantage in New York, New Jersey, and Pennsylvania. Twenty-eight per cent of the farms in Massachusetts were equipped with gas or electric lights. In Utah, where many farmers live in villages after the European manner, 43 per cent of the farmers' homes had gas or electric lights, and in California 26 per cent. In telephone installation the percentage of farms enjoying this great advantage ran up to 86 per cent in Iowa, 78 per cent in Kansas, 76 per cent in Nebraska, 73 per cent in Illinois, 66 per cent in Indiana, and 62 per cent in Minnesota and in Missouri. It is evident from these figures that farmers will have improved household facilities when the opportunity exists.

The architecture of the farm house needs study. Houses built to fit farm wants need not lack either beauty or convenience. Part of the money provided for the farm home should be set aside for shrubbery and other adornments. It should be easy to plant the lesson of beauty in the minds and hearts of rural young people, so that when they become farmers their desires will not be limited to the

attainment of economic security, but will include also the provision of beauty and harmony in the home and its surroundings. Instruction given to the young people of the farm in home decoration will return its cost a thousandfold. It should be emphasized, however, that the problem is not merely to transplant to the farm what has already been worked out by the city, but rather to adapt improved appliances to the special needs of the farm home.

CHANGES IN DEPARTMENT ORGANIZATION

During my term of office the improvement of the department's organization has been sought by carrying out, as far as practicable, the principle of segregating research and regulatory work into separate administrative units. The purpose of this separation is twofold: To free the scientists from regulatory duties which invariably distract their attention from research work; and to provide for more effective administration by grouping within a single organization the work of enforcing all the statutes dealing with the same industries or operating within the same general field.

This reorganization has been effected by increasing the duties of some units and by creating new units for the administration of specific statutes. There has been consolidated in one unit, known as the Bureau of Chemistry and Soils, the work conducted by the former Bureau of Soils and the Fixed Nitrogen Laboratory and some of the chemical work conducted by the former Bureau of Chemistry and the Bureau of Plant Industry. All the regulatory work formerly administered by the then Bureau of Chemistry and the Insecticide and Fungicide Board is now under a unit known as the Food, Drug, and Insecticide Administration.

The Packers and Stockyards Administration has been abolished and responsibility for the enforcement of the packers and stockyards act of 1921 transferred to the Bureau of Animal Industry. Since several other laws relating to the livestock industry are enforced by the same bureau, this change in organization has provided for centralized administrative authority in the enforcement of statutes relating to traffic in livestock and has reduced the number of independent subdivisions dealing with a single industry.

A new unit, designated as the Plant Quarantine and Control Administration, has recently been established, and has taken over the work of preventing the entry of insect pests and plant diseases into the United States, and of controlling the spread of pests already established in the country. These functions were previously discharged by the former Federal Horticultural Board, the Bureau of Entomology, and to a limited extent by the Bureau of Plant Industry. I am convinced that the new arrangement will insure better protection for our crops, and will permit more effective research work by the units that have been relieved of responsibility for regulatory work.

The Personnel Administration

A little more than three years ago nine separate offices concerned with the business administration of the department were consolidated into one organization, known as the Office of Personnel and Business

Administration. Responsibility for the supervision and coordination of the general business activities of the department was delegated to the Director of Personnel and Business Administration. This organization has expedited work, eliminated confusion and waste by establishing a more orderly and efficient business procedure and effected greater uniformity in the organization of the business offices in the department.

Independent points of contact have been reduced in number and executive leadership has been focussed on a smaller number of administrative units. The personnel has developed a greater sense of responsibility and a keener spirit of organization, loyalty, and pride in accomplishment. Separation of regulatory from research and service functions has improved the department's relations with the public. When these duties are administered by the same bureau, the enforcement of regulatory statutes may interfere with the cordial and sympathetic relations necessary for advantageously carrying on research. Research workers are now able to maintain effective contacts with outside agencies without being embarrassed by possible differences arising between those agencies and the regulatory units of the department.

Enlargement of scientific knowledge may be impeded by the administrative responsibilities frequently imposed upon outstanding investigators. After years of meritorious service devoted to administrative work it seems fitting that members of the department who have attained distinction in science should be relieved of executive responsibilities, so that they may devote all their energies to research. Accordingly, at their own request, I have relieved from further administrative duties the former chief of the Bureau of Biological Survey, E. W. Nelson, an internationally recognized leader in the study and conservation of wild life; the former chief of the Bureau of Entomology, L. O. Howard, long recognized as a distinguished investigator in entomology; and the head of the office of foreign-plant introduction of the Bureau of Plant Industry, David Fairchild, eminent agricultural explorer and authority on foreign-plant introduction.

On June 30, 1928, the department had on its rolls 22,189 employees, of whom 4,902 were located in the District of Columbia and 17,287 stationed in the field service. This was an increase of 111 in the District of Columbia and of 417 in the field service over the number of employees in the department on June 30, 1927.

Decline in Turnover

The turnover in the personnel during the fiscal year 1928 was 9.5 per cent, or 1.19 per cent less than for the preceding year and 4.31 per cent less than for the fiscal year 1924. The lower classification grades continue to show the higher turnover. In the Washington force 60 per cent of the total turnover occurred in the first three grades of the clerical and custodial services. The turnover of scientific employees was 5.8 per cent of their number, 69 per cent of this turnover occurring among employees receiving \$3,600 or less. Sixty-

four per cent of the scientific employees who resigned during the year left the service to accept positions which afforded either a higher salary or a better opportunity for advancement.

The employment situation in the department shows marked improvement, both in a steady decline of turnover in personnel and in increased loyalty, cooperation, and devotion to duty. Some of the factors which have contributed to this gratifying condition are a rise in the average of salaries, a reduction of inequalities in compensation for positions involving like duties and responsibilities, greater opportunity for advancement afforded under the personnel classification act, consistent promotion from within the ranks, and the prospect for better housing conditions which will be afforded by the new buildings for which Congress has made provision.

The policy of the department is to give adequate recognition of meritorious service by providing more responsible employment and suitable financial rewards. I want every employee to feel that he shares in the responsibility for the welfare of the department and for the service which it renders. That this feeling prevails is apparent from the esprit de corps which now exists among department workers.

Increases in Salaries

Attractive opportunities for workers now exist in all the department's activities. On July 1, 1924, following the increases due to the classification act, the average salary of permanent employees in Washington was \$2,052. On July 1, 1928, including the increases provided under the Welch Act, the average salary had risen to \$2,292, an increase of \$240. Similarly, on July 1, 1924, the average salary of permanent field employees was \$2,091, and on July 1, 1928, it had risen to \$2,411, an increase of \$321. During the last four years there has been a marked improvement especially in the salaries of workers in the professional and scientific grades. On July 1, 1928, the average salary of Washington employees in these grades was \$3,894, which represents an average increase of more than \$500 over the average salary in these grades on July 1, 1924. In consequence of this improved situation the department is in a more favorable position than ever before to offer substantial inducements to qualified research men to enter the service.

During the fiscal year ended June 30, 1928, 101 employees were retired on an average annuity of \$807.45. Of these, 76 were retired on account of age, 23 on account of disability, and 2 on account of reduction in force. Notwithstanding the increased annuity provided by the retirement law as amended in 1926, many employees who have reached the age of retirement prefer to continue in the service, since the present retirement pay is insufficient for the needs of those who have dependents.

The numbers and average annuities of former employees of the department retired since the enactment of the general civil service retirement act are shown in Table 1.

TABLE 1.—*Number and average annuities of former employees of the Department of Agriculture retired since 1921*

Fiscal year	Retired on account of age		Retired on account of disability		Retired on account of reduction in force		Total	
	Number	Average annuity	Number	Average annuity	Number	Average annuity	Number	Average annuity
1921.....	102	\$574.08	28	\$528.94	-----	-----	130	\$564.35
1922.....	8	482.18	13	491.27	-----	-----	21	487.81
1923.....	16	620.56	22	496.05	-----	-----	38	548.48
1924.....	21	596.45	10	457.56	-----	-----	31	551.65
1925.....	26	597.52	15	482.78	-----	-----	41	555.55
1926.....	17	727.02	17	571.88	1	\$527.44	35	643.96
1927.....	34	755.39	33	716.96	1	821.16	68	737.71
1928.....	76	825.77	23	769.89	2	543.30	101	807.45

Sick-Leave Regulations

There is a widespread but mistaken impression that employees regularly take the full allowance of annual and sick leave which may be granted in accordance with the law. A survey of the leave situation in the department covering the calendar years 1921 to 1927, inclusive, shows that for employees in the District of Columbia the average number of days of annual leave was 26.9, and that only 54 per cent of the employees took the full allowance of 30 days of annual leave. For the same period the average number of days of sick leave was 7.4; only 5.1 per cent of the employees took the full allowance of 30 days of sick leave and 28 per cent of the employees took no sick leave. On an average 9.5 per cent of the employees took the full allowance of both annual and sick leave.

The leave allowance of employees outside of the District of Columbia is governed by a special law, which provides that the Secretary of Agriculture may grant leaves of absence not to exceed 15 days in any one year and an additional 15 days in cases where an employee is ill. For the 7-year period 1921 to 1927 the average number of days of annual leave of employees outside of the District of Columbia was 12 and the full allowance of 15 days was taken by only 49 per cent of the field employees. The average number of days of sick leave was 3; only 6.8 per cent took the full allowance of 15 days of sick leave and 53 per cent of the field employees took no sick leave. Both in Washington and in the field the average amount of sick leave taken by men is approximately one-half that taken by women.

Although 30 days sick leave is far in excess of the requirement of the average employee, cases of protracted illness, in which the allowable 30 days is exhausted before the employee is able to return to duty, are not infrequent, and the additional time required for recovery must be taken as leave without pay. During the calendar year 1927 $2\frac{1}{2}$ per cent of the department's employees in Washington found it necessary to take leave without pay in addition to the 30 days sick leave with pay. As a measure of relief from this situation I favor legislation which will recognize cumulative sick leave as a means of mitigating the hardships suffered by deserving employees who may occasionally need an unusual amount of sick leave.

HOUSING SITUATION OF THE DEPARTMENT

During recent years the housing situation of the department in Washington has become deplorable. The 19 major units of the department occupy about 40 buildings, some of them in widely scattered locations. Units of some bureaus are scattered in as many as 8 or 10 buildings. It would be difficult to overestimate the loss to the Government in impaired efficiency of administration and operation caused by this unsatisfactory situation. Congested offices and overcrowded laboratories are found in practically every branch, thus making impossible maximum efficiency of the staff of the department. Delays and confusion are encountered in the transaction of public business, intercommunication is made difficult instead of convenient, and the task of coordinating the work of the department is greatly complicated. Persons who call at the department, many of them from out of Washington, frequently find upon reaching the administration building, which is in a location somewhat remote from the business section of the city, that the particular office with which their business is to be transacted is in another part of the city. A number of the offices have been assigned space in the unsatisfactory temporary buildings erected as an emergency measure to house war activities. Not only are valuable records in these buildings exposed to undue hazard but the efficiency of the work is greatly reduced. While many of the buildings, such as the temporary war buildings, are Government owned, it has been necessary for Congress to appropriate more than \$1,500,000 to meet the rent bill of the department during the past 10 years.

Any program contemplating the full measure of constructive public service from the funds invested in the Department of Agriculture must have among its first objects the remedying of this fundamental difficulty under which the department labors. All the offices and laboratories in Washington should be concentrated as rapidly as possible in buildings on or adjacent to the departmental reservation on the Mall. Bureaus whose work is closely related should be located in proximity to each other, and all units of each separate bureau should be under the same roof. Such a plan would permit much more effective organization of the work, better and more economical business operation, and closer administrative supervision.

Provision for Growth Needed

An essential part of a permanent program to meet the need for adequate housing is provision for growth. The development of the department since 1908, when the present east and west wings were completed, has been so great that the space estimated at that time as sufficient to house the entire department is now insufficient to house adequately two of the larger bureaus. With the increased growth of the United States and accompanying changes in our systems of marketing and distributing agricultural products, continued development of the Department of Agriculture may be expected. Housing for these activities should be planned now and not left haphazardly to the future.

Legislative provision has recently been made to relieve this unsatisfactory situation. Congress has authorized an appropriation of

\$2,000,000 for the construction of a central administration building to connect the east and west wings completed in 1908, and good progress has been made on this unit during the past year. This building, which should be completed by the spring of 1930, will permit the concentration of all general administrative and business units of the department. The administration building is monumental in design and with the connecting wings will contribute much to the beauty of the Mall. It will be one of the finest Government buildings in Washington and will represent agriculture in a fitting manner. However, completion of the administration building will not in itself add to the amount of floor space available to the department, because the group of unsightly structures which have been erected on the Mall from time to time during the past 50 years will have to be removed.

Additional Buildings to Be Erected

The need for additional space will be met by the acquisition of land adjoining the department's reservation on the Mall, and the erection of large modern office and laboratory buildings. Congress has authorized an appropriation of \$5,750,000 for this purpose, of which \$2,200,000 already has been appropriated. These new buildings, while not of the same character as that of the buildings to be erected on the Mall proper, will be of attractive design and substantial construction, and well adapted to the department's needs. Present plans contemplate construction of the first unit, which will contain 321,000 square feet of floor space, as soon as title to the land can be acquired. The buildings south of the Mall will be of the extensible type, to provide for future growth. This should prevent recurrence of the present unsatisfactory situation.

In viewing the developments of the department during the past four years, it is difficult to select any one of greater importance than the progress now being made in meeting the housing situation. The splendid cooperation of the Public Buildings Commission and of the Office of the Supervising Architect of the Treasury Department, which are charged with the actual planning and construction of the buildings, is an important and much appreciated factor.

REGULATORY WORK WINS COOPERATION

Important developments have taken place in the department's regulatory work during the last few years. Fifteen or more principal regulatory laws, and a larger number of subordinate ones, are administered by the department, in a spirit which I believe tends to obtain a maximum of compliance with a minimum of difficulty and resistance. This is accomplished by emphasizing service features rather than penal clauses, and by making it clear that producers and consumers alike have an interest in impartial law enforcement. It is characteristic of all the regulatory laws, in a varying degree, that they involve the control of commercial agencies. The department seeks to protect the public in the manner contemplated by the statutes by a policy of education and of cooperation with the commercial agencies concerned. I can not describe the regulatory activities of the department in detail, but their nature may be illustrated by a typical example. In this way the general policy and purpose of the

department's regulatory work can be indicated, while at the same time an account is given of certain developments of great practical importance and value to agriculture and also to the Nation.

Criticism of the Federal grain standards act has long since dwindled to insignificant proportions. It is now generally recognized that the penal provisions of this law have no other purpose than to promote a uniform method of grading in the general interest. Occasionally some section of the country, where smut or other damage has been extensive, may agitate for an indulgent application of the Federal grades. This feeling, however, generally gives place to a realization that the ultimate results of any such relaxed application of the standard would be harmful. Precedents of that sort would inevitably lead to the destruction of the grading system, and would not benefit the favored region more than temporarily. As soon as it became known that the bars had been let down by the grain inspectors, the market would reflect the fact in falling prices. Farmers would thus be no better off than had they allowed their grain to be graded strictly in accordance with the law.

In judging the utility of the Federal grain standards act, which became a law in August, 1916, it should be remembered that prior to its passage there was a total lack of uniformity in the standards for grades of grain throughout the United States. Commercial grades were established either by commercial boards of trade or chambers of commerce except in about half a dozen States which had enacted laws providing for grain grades and grain inspection. Under that system, or rather lack of system, grade terms meant different things in different places. With grain marketing on an interstate and foreign commerce basis, State or local control of grades and inspection services was hopelessly inefficient. Foreign buyers complained that they could not buy grain intelligently under a multiplicity of grades and under conditions which inevitably created lack of confidence in grade certificates.

Immense Improvement Effected

Accordingly the way was paved for the Federal Government to enter the field, and official standards under the grain standards act were promulgated for shelled corn in 1916, for wheat in 1917, for oats in 1919, for rye in 1923, for grain sorghums in 1924, for feed oats and mixed feed oats in 1925, and for barley in 1926. The result was an immense improvement in the facilities for doing business in grain. As is usually the case with new and complex legislation, the law was often violated in the early days of its enforcement. To-day, however, its requirements and prohibitions are generally known and infractions of the statute have largely ceased.

How uniform standards correctly applied in all markets promote the interests of all concerned is shown by the results following the establishment of Federal standards for barley in 1926. Barley grown east of the Rocky Mountains has been almost wholly on an export basis since the enactment of the Volstead Act. It has moved to the United Kingdom and continental Europe, where it is used almost exclusively for feed. Yet prior to the establishment of Federal standards American barley was sold to foreign buyers as

"48-pound malting barley." It was inspected and graded into ocean carriers under that name. But 48-pound malting barley did not mean the same thing at any two markets, either at inland points or along the seaboard. This situation led domestic dealers, exporters, and foreign buyers to unite in a request for the establishment of Federal barley standards, and since that request was granted no major difficulties in the merchandising of barley have arisen.

True to its policy of administering the grain standards act as essentially a service statute the department takes frequent counsel with the grain trade on problems involving policy and procedure. This is done so that the law may be administered in the light of what is considered good commercial practice, good business ethics, and well-recognized trade custom. In consequence, a high degree of cooperation in the enforcement of the law has been developed between Federal officials and the grain trade. Evidence of the satisfactory manner in which grain standardization is effected appears in the marked degree of uniformity that has been established in the application of the grades. About 450 inspectors apply the Federal grain standards in 150 markets. These inspectors perform something like 1,500,000 inspections a year. It might be supposed that the grading work done by so many different men at so many different points would show considerable variation. This is not the case, as can be seen from the following illustration showing grading at two markets in the same State during July, 1928. Each market received approximately 25,000 cars of wheat, the bulk of which was shipped direct from country stations. Both markets drew the wheat from the same general territory. Although the grain was inspected and graded in the two markets by many different inspectors, the receipts for the month fell closely into the same numerical grades, as Table 2 illustrates:

TABLE 2.—*Grading of wheat in two markets in the same State during July, 1928*

Grade	Market A (25,499 cars)	Market B (22,268 cars)	Grade	Market A (25,499 cars)	Market B (22,268 cars)
	<i>Per cent</i>	<i>Per cent</i>		<i>Per cent</i>	<i>Per cent</i>
1.....	43.2	48.8	4.....	8.5	7.6
2.....	31.4	30.3	5.....	.8	.6
3.....	12.0	11.2	Sample.....	6.3	3.4

Disputes as to Inspections

Sometimes disputes arise as to the accuracy of grain inspections. Since grading is not an exact science, provision is made for appeals from the judgment of licensed inspectors. In one case recently, for example, a large volume of grain moving in carload lots was certificated as No. 2 hard winter wheat at the shipping point. On arriving at its destination, this grain was certificated by another inspector as No. 3 and No. 4 hard winter wheat. Accordingly an appeal was taken to the Federal supervisor. The supervisor sustained the grading given at the destination point. Another appeal was taken to the Federal Grain Supervision Board of Review at Chicago. This board likewise decided that the grain should be graded

No. 3 and No. 4, whereupon the shipper carried a final appeal to the Secretary of Agriculture. The case afforded an opportunity to learn whether the Federal grain supervisors were interpreting the wheat standards in line with good commercial practice. I, therefore, called upon each of the presidents of the five principal grain exchanges handling hard winter wheat to appoint from their membership a committee of experts to examine and report on the samples of wheat in question. Each of the committees found that the wheat had been properly graded as No. 3 and No. 4 and that it would not meet the requirements for grade No. 2.

Grain Futures Administration

Closely connected with the United States grain standards act is the United States grain futures act of September 1, 1922. At the beginning of my administration the enforcement of the grain futures act was still in an experimental stage. Since then much progress has been made in eliminating faulty practices and in promoting better understanding among the general public as to the functions and operations of the grain futures markets.

Valuable results have come from formal cooperative agreements entered into in 1925 with the principal grain exchanges. These agreements recognize that the grain trade is willing and anxious to keep within Federal laws, and is in a position, through the grain exchanges, to cooperate with the department in preventing infractions. In making these agreements the department has not divested itself of any responsibilities or ceased to recognize its exclusive obligations to enforce the laws which it is required to administer. Prevention, however, is better than correction, and this end can be promoted by invoking the influence and disciplinary power of the grain exchanges in the maintenance of approved trade practices.

It is believed, in other words, that faulty trade practices can be more effectively prevented through cooperation with the grain exchanges than by arbitrary procedure. Accordingly the Chicago Board of Trade and other contract markets have set up business-conduct committees with broad powers over the business conduct of members and power also to limit daily fluctuations in grain prices during emergency periods. These committees cooperate closely with the grain futures administration. They have accomplished results that fully demonstrate the value of this means of handling critical market conditions. Workable plans are being put in operation for dealing with the many disturbing factors which unduly influence prices in the grain futures markets.

It has been demonstrated by investigations made in connection with the enforcement of the grain futures act that large-scale speculative practices by a few individuals often play an important part in price movements, with but little regard for supply and demand conditions. In some instances individuals have accumulated long or short lines of 5,000,000 bushels or more.

Speculative holdings by individuals have occasionally exceeded 10,000,000 bushels. There have also been days when the volume of trading by a single person has exceeded 10 per cent of the business done during that day in the principal grain future. Such large-scale operations may be a very disturbing element in the market; in

fact domination of the market by a few large-scale speculators always results in abnormal price changes. Although the grain futures act enables the department to obtain information about individual commitments in the various futures, it does not provide authority to prevent excessive trading. I believe the act should be amended so as to prohibit excessive trading for purely speculative purposes, and legislation contemplating this change was introduced at the last session of Congress. Such an amendment should contribute greatly toward the prevention of abuses in grain trading, without imposing any unnecessary or harmful restrictions on legitimate trading.

Regular Publication of Futures Data

One of the greatest benefits resulting to the public from the enforcement of the grain futures act is the regular publication of information pertaining to trading in grain futures markets. Previously no reliable information of this character was available. Lack of it possibly facilitated abuses on the one hand and on the other hand gave rise to extreme views as to the influence exercised by grain traders on grain prices. Under present conditions information as to the volume of trading in grain futures and also as to open commitments is made available to all persons interested. In August of this year the information service was extended to include daily releases showing both the volume of trading and the aggregate open commitments by futures. This information should help to eliminate "squeezes" and "corners" in the closing days of an expiring future, an advantage that no one familiar with the grain trade will underestimate.

When the grain futures act was first put in effect some grain traders predicted its effect would be to discourage trading in futures, and thereby to narrow the grain market and increase price fluctuations. But the volume of trading in futures has increased instead of diminishing. Last year, for example, the volume of trading in grain futures was no less than 18.4 per cent greater than the average for the two years immediately prior to the enforcement of the act. Total sales for future delivery on all contract markets aggregated 20,903,549,000 bushels compared with 19,964,384,000 bushels in the preceding year. This increase, which amounts to 4.7 per cent, is conclusive evidence that the grain futures act is entirely without the discouraging influence on trading in grain futures which its opponents predicted it would exercise. As in former years, trading in wheat continues to constitute more than half the business done in grain futures. Last year 53.6 per cent of the total volume of trading was in wheat, 37.4 per cent was in corn, and 6.1 per cent was in oats. The remaining 2.9 per cent represented trading in rye, barley, and flax futures. The Chicago Board of Trade handled 86 per cent of all the trading done in grain futures.

Other Regulatory Laws

The problems presented in the enforcement of the laws relating to grain have their counterpart in the administration of other important regulatory statutes, such as the plant quarantine act, the meat inspection act, the food and drugs act, and the insecticide and fungi-

cide act. These laws are not all equally characterized by what have been termed "service features." All, however, are intended for the protection of agriculture and the welfare of the Nation. It is invariably helpful to enlist the hearty and intelligent cooperation of the interests subject to the laws, so that voluntary action may be substituted for the compulsive correction of improper practices. Most violations of the regulatory laws result from lack of information about their requirements. This obstacle is progressively lessened by the contacts which the department must establish with trade agencies. The department's policy of an advisory rather than an arbitrary attitude has been abundantly justified by results not only in the shape of more easy discharge of necessary administrative functions but in substantial advantages to manufacturers, shippers, and others.

Packers and Stockyards Act

In the enforcement of the packers and stockyards act by the Bureau of Animal Industry a valuable activity has been the preparation of data on the larger stockyards in the Middle West for use in the valuation of stockyard properties and the study of stockyard rates. This work was carried on at 10 markets, and comprises the valuation of stockyard properties, of the financial results of stockyard operations, of the competitive relationship of various markets, and of the services rendered. This information is required as a basis for determining and prescribing just and reasonable rates and charges for stockyards' services.

Informal adjustments of numerous complaints are made, especially with respect to price, quality, and weight of feed, shortages in count and loss of animals in the yards, errors in accounting, and the handling and sale of crippled livestock. In more serious cases formal proceedings are instituted. But the number of such cases is relatively small, and every effort is made to press hearings to a conclusion so that final decisions can be rendered with minimum delay. In a few exceptional cases resort to the criminal provisions of the act is necessary. In the last year a few persons were indicted, pleaded guilty, and were fined. Practically all market agencies and traders have complied with the provisions of the act requiring them to furnish bonds. This action, accomplished largely by informal procedure, greatly increases the protection of producers and shippers.

The interests of livestock shippers are safeguarded by constant supervision of the operation and maintenance of scales at public stockyards, and, on the whole, conditions in the weighing of livestock have been materially improved. A number of yards have installed small scales for weighing small drafts.

ANIMAL INDUSTRY PROBLEMS

The campaign against tuberculosis of livestock, which the department is conducting in cooperation with State and local officials, has made excellent progress in the volume of tuberculin testing and in the extent of territory in which systematic testing has been completed. In some months during the fiscal year 1928 the number of cattle tested exceeded a million head, and the total number during the year was approximately 11,300,000. The progress of the work

has been marked by a decline in the percentage of reactors found, showing gradual eradication of the disease. The estimated extent of bovine tuberculosis in the United States is now officially estimated at about 2 per cent, compared with 4 per cent shortly after the cooperative tuberculosis-eradication work began about a decade ago.

The testing of individual herds is supplemented by efforts to eliminate the disease from entire communities, counties, and States, as well as from individual farms. The number of counties engaged in this work exceeds 1,100 and is rapidly increasing. Similar public interest is revealed in the increasing number of cities and towns requiring the tuberculin testing of cattle that contribute to urban milk supplies. A survey of milk ordinances shows that fully 2,100 municipalities require either the tuberculin testing of cattle or the pasteurization of milk. In about three-fourths of these cities and towns the tuberculin test is compulsory. The remainder permit a choice between pasteurization and tuberculin testing. There has also been a decline in tuberculosis among swine, as shown by records of the Federal meat-inspection service. Considering the magnitude of the livestock industry and the task of detecting and eradicating so insidious a germ disease, the present status of the campaign against tuberculosis is gratifying.

Hog-Cholera Prevention

Owing to the effectiveness and wide use of the preventive-serum treatment, hog cholera, which at one time caused heavy losses and disheartened swine growers, is no longer a limiting factor in hog production. The department maintains a corps of trained veterinarians who investigate outbreaks, hold demonstrations of control methods, conduct educational work for the prevention of the disease, and aid State and local authorities in keeping it under control. The preventive-serum treatment continues to undergo various refinements, including the increasing use of improved types of serum. Records of the Bureau of Animal Industry, which supervises the manufacture of veterinary biological products, show continued increase in the exports of such products. The exports consist chiefly of antihog-cholera serum, indicating that foreign countries find the preventive-serum treatment of economic value.

Despite various obstacles the systematic eradication of cattle ticks from the Southern States goes forward, and each year more territory is reclaimed from this pest. The tick-infested area has been reduced to about 25 per cent of its original size. South Carolina and Virginia were released last year from the Federal quarantine against cattle ticks, and Oklahoma has nearly completed its tick-eradication program. Many southern communities which recently completed the eradication of cattle ticks are already benefiting from the introduction of improved cattle for breeding. In a part of eastern Georgia, where purebred beef bulls were introduced two years ago, livestock owners now are furnishing feeder cattle in carload lots. Two counties in western Florida recently received their fourth carload of purebred breeding stock for the establishment of improved herds. Similar activities are in progress in tick-free areas in Oklahoma. Commercial dairy and beef development, such as the establishment

of creameries, ice-cream factories, and meat-packing establishments, have followed closely in the wake of tick eradication. The Southern States have been untiring in supporting this campaign.

Inroads of Animal Parasites

Developments in research and regulatory work have directed attention to the serious inroads which many animal parasites make among domestic livestock. Although certain well-known pests, such as cattle ticks, scab mites, and roundworms of swine, are being reduced, hordes of other parasites continue to take enormous toll. The attacks of these pests explain why many young animals die or become unthrifty. Some parasites, notably liver flukes, are invading new territory. The economic losses caused by animal parasites are without question greatly underestimated, since they not only reduce vitality and delay maturity, but also invade tissues and organs and cause a loss of meat. The identity of parasites affecting domestic animals is readily determined in most cases, but effective control measures for many parasites are yet to be developed.

To cope more fully with this situation, the department is extending its research activities. Work thus far conducted has yielded excellent dividends in practical benefits to stock owners. The cooperation of the public in reporting losses and aiding the department's investigators is requested.

Inspection services conducted by the Bureau of Animal Industry give valuable results. Federal meat inspection was conducted during the fiscal year 1928 at 829 establishments in 255 cities and towns throughout the country. Department inspectors supervised the conversion of 75,000,000 head of livestock into more than 13,000,000,000 pounds of dressed meat and lard to supply interstate and foreign demand. During the year 1,155,710,000 pounds were exported under official certification. This efficient service detects infectious centers where diseased animals originate, eliminates unfit meat from the food supply, insures wholesomeness, clean handling, and truthful labeling, and stimulates foreign purchase of our meat. The meat-inspection service covers about two-thirds of the meat supply of the entire country and is conducted at a cost of only one twenty-sixth of a cent a pound for dressed meat and lard.

Another important and extensive branch of livestock work is the enforcement of animal quarantine and transportation laws and of regulations governing the importation and exportation of livestock. In supervising the interstate transportation of livestock in the fiscal year 1928, department employees at market centers inspected approximately 19,000,000 cattle, 21,000,000 sheep, and 43,000,000 hogs. Large numbers of these animals were dipped so that they might be handled in interstate commerce. Department employees supervised the immunization and disinfection, against hog cholera, of more than half a million swine.

Inspections of Cars

The scrutiny of animals for the purpose of preventing the spread of diseases and parasites is supplemented by inspections of cars, of which more than 33,000 were found during the fiscal year 1928 to

have carried animals affected with communicable diseases. These cars were cleaned and disinfected under Federal supervision. About 40,000 additional cars were cleaned and disinfected to comply with department regulations or at the request of State officials and transportation companies.

The department's supervision over establishments licensed under the virus serum toxin act has shown a general compliance with that law and with supplementary regulations to insure purity and potency in biological products. The need of such supervision may be seen in occasional violations which have resulted in the revocation or suspension of licenses. Recent causes have included improper methods, false records, insanitary conditions, and other irregularities. Strict enforcement of this act is necessary to provide the livestock industry with pure and potent biological products which may be used with confidence in preserving the health of animals.

Many problems in the breeding, feeding, and management of domestic livestock and poultry are under investigation. Each year adds new results for the guidance of stock owners. Recent surveys of ranch organization and methods of production in several typical areas of the West should benefit cattle, sheep, and goat producers. The results enable a ranch owner to compare his methods, investment, and returns with those of typical ranches. Wide variation in ranch methods and financial returns exists, and many stock owners may profit by studying the management of the most successful ranches.

Cooperation with Experiment Stations

In response to the need for more information concerning factors influencing the quality of meat, the department is cooperating with 20 State experiment stations and other agencies in seeking the causes of tenderness, color, palatability, and other characteristics of this food.

The investigations extend from the breeding of the animals to the cooking of the meat. In beef, tenderness apparently depends on the quantity and character of connective tissue and on the length and arrangement of fibers. There appears to be no close relation between dark color and either tenderness or palatability.

Experimentation is contributing useful new knowledge of the most profitable methods of beef production. The feeding of supplemental grain rations to steers fattened on grass has materially increased the quantity, quality, and profitableness of the beef produced.

Nutrition studies conducted by the department with hogs at several farms have shown the economy of finishing hogs for market at early ages. In view of the market's growing preference for lighter-weight hogs, the selection of types which develop early is of greater importance than formerly.

Results of Sheep Investigations

Sheep investigations have shown the influence of many factors, such as age, fineness of staple, and face covering, on the yield of wool. Objections to so-called wool blindness resulting from extreme covering of wool on the face appear to be well founded. This condition

is associated with a lighter total fleece weight compared with similar sheep having less wool on the face. Studies of this character throw new light on the desirability of having show-ring standards conform with the practical utility of domestic animals.

The department's efforts toward improving its stud of Morgan horses, maintained at Middlebury, Vt., have resulted in increases in weight and height and in the development of stamina and other desirable qualities. Morgan horses bred and developed by the department have performed creditably in recent endurance rides and have won prizes at expositions. A promising new branch of the department's horse investigations is a series of feeding experiments now in progress in cooperation with the War Department. Cavalry and artillery horses are used in tests to determine the possibility of variations from the standard ration used in the Army, with the aim of reducing the cost of feed.

Investigations in poultry production have shown that for best growth and egg production the rations should contain approximately 18 per cent protein. Whether the source of the protein be meat scraps or dry skim milk seems to make little difference. The rations for both growing chicks and laying hens should be properly balanced in minerals, especially calcium and phosphorus. The addition of sulphur in certain forms has proved beneficial in increasing egg production and promoting the growth of feathers. Systematic breeding methods have led to an increase in average egg production per bird in the flocks of Barred Plymouth Rocks, Rhode Island Reds, and White Leghorns on the department's farm at Beltsville, Md. Close inbreeding has resulted in increased embryo mortality during incubation and has retarded the rate of maturity of the chicks that hatch.

Betterment of Animal Types

As in the past, the department has supported various extension efforts to improve domestic animals. An interesting world survey on the subject reveals a keen interest in the betterment of animal types in the principal livestock countries. There is universal reliance on the use of selected purebred sires to bring about improvement in animal types. Many countries are fostering educational methods, breeding centers, and various forms of direct assistance to livestock owners, to improve the quality of products and win a larger proportion of world trade. Improvement of livestock in the United States is essential to the future welfare of the industry, since competition in the production of better animals is developing throughout the world.

Investigations regarding the bacilli of tuberculosis have resulted in the production of an artificial medium capable of yielding a more abundant growth of the bacteria than ever before. This discovery is of value in the making of tuberculin, the diagnostic agent used in the campaign against tuberculosis in cattle, swine, and poultry. An efficient disinfectant for sausage casings, which serves as a cleaning and purifying agent and removes practically all bacteria, has been developed. Investigations have confirmed earlier work which indicated that pork is a food relatively rich in the antineuritic vitamin.

Increasing losses caused by that baffling disease, infectious abortion, have necessitated an active program of research to develop

better prevention and control measures. Investigations have shown new facts concerning both natural and artificial immunity. These studies will be energetically pursued, for the toll of the disease probably exceeds \$50,000,000 annually, and a pressing need exists for more effective means for its control. Meantime, cattlemen can do much to control the disease by reducing the amount of infection that comes near susceptible animals. Indiscriminate mingling of healthy and diseased animals contributes greatly to the spread of the malady.

A special research committee of the department is studying bacillary white diarrhea of young chickens. This disease causes heavy losses, and a pressing need exists for improved control measures. The first problem is the effect of incubators on the spread of the disease. This portion of the work is nearly completed. Other intensive research on the disease is in progress.

Foot-and-Mouth Disease

A comprehensive report prepared by the department's foot-and-mouth disease commission, which studied that disease in Europe, is now available. This valuable document shows that the greatest danger of spreading the disease occurs in its early stages. The experiences of European countries in attempting to control the malady confirm the methods of eradication which have proved successful in the United States. Under conditions prevailing in this country prompt diagnosis of the disease followed by the slaughter and the burning or burying of affected or exposed animals is especially desirable.

The danger of a shortage of trained veterinarians, mentioned in my last report, has been somewhat lessened by a larger attendance in accredited veterinary colleges whose graduates are eligible to take civil-service examinations for veterinary positions in the department. The registration for the college year 1927-28 was 723, compared with 666 for the preceding year. This increase took place largely in the freshman class. Evidently more young men are being attracted to the veterinary profession. The situation is further helped by the higher salaries the department is now paying veterinarians. An average increase of \$153 was made possible by the recognition by the Bureau of the Budget and Congress of the need for reducing the discrepancy between salaries paid veterinarians and other scientific workers in the department.

RESEARCH IN PLANT INDUSTRIES

The progressive farmer, from the very nature of his profession and regardless of nationality or region, must have an alert and inquiring mind and constantly must utilize his new observations or the new information he may have obtained from others, in order to raise, to protect, and to improve his crops. The great wealth of information upon which our modern agriculture is based teems with ideas developed or at least partially originated by thoughtful men actually cultivating their own land, and endeavoring better to understand and to improve their crop production. In the United States the stimulating influence of our farmer pioneers, with their genius for overcoming the diverse and unusual obstacles to a successful agri-

culture in a new country, has played a large part in making our Nation a leader in agricultural investigation.

The present era requires group action rather than individual action. In research as in other lines of endeavor the need for more complete and new information to meet the new and important problems constantly arising with our more complex crop production is too urgent to permit us to wait for the gradual accumulation of individual experience. The resources of our agricultural colleges as well as of this department are now supplementing and enormously enlarging the experimental activities formerly left to the progressive landholder, but now clearly recognized as a paramount national responsibility.

The rapid centralization and specialization of agricultural research during the last few years have made possible greater accuracy and also greater speed in obtaining reliable results. It is not too much to hope that future years will lead to more and more effective organization for solving important agricultural questions, and we may accordingly expect steadily increasing benefits to American agriculture and to the Nation as a whole.

Research Cost Returned Manyfold

Attempts to reckon the money value of scientific research are never very successful. Discoveries that seem unimportant at first may turn out to have immense significance later. It is difficult to measure the economic results even of achievements the practical utility of which is obvious, since their effect may be felt in diverse ways by many industries simultaneously. Unquestionably, however, the work done by the Bureau of Plant Industry in the last few years has saved immense sums, not only to farmers but to the Nation as a whole. This can be demonstrated without trying to give an accurate monetary expression of the economic gains realized. Whatever reduces the cost of production or leads to the creation of new use values helps to solve our economic problems. Judged by this criterion, the work of the Bureau of Plant Industry is abundantly justified. It has promoted national progress in agriculture by the interpretation of facts and by the discovery and application of scientific principles to crop production and plant growth.

Space limitations oblige me to cite only a few of the bureau's recent contributions to farm efficiency. These citations should be regarded as typical rather than exceptional cases. In a brief review it is impossible to mention all the many complex and important research results for which credit may be claimed. I hope the examples given will lead to a better appreciation of the essentially practical aspects of the bureau's scientific investigations, and of the manner in which those investigations touch the lives of individual farmers.

The work of foreign plant introduction is of increasing importance to our country. Through such activity new plant material is supplied from the world's varied array of plant possibilities, not only for the improvement and extension of established plant industries but also for the development of new-crop enterprises adapted to the requirements and needs of America.

Nine months of exploration in British East Africa, ended in February, 1928, resulted in the collection of more than 160 kinds of

seeds of different grasses and other forage-crop plants adapted for trial both as pastures and meadows in the North and South. Extensive studies were made of the regions visited, with a view to determining their agricultural aspects as a probable factor in the future development of the economics of world agriculture.

A large collection of interesting and valuable Chinese bamboos, seeds, and other propagating material of new plant possibilities were received from Canton, China, before the development of the domestic conditions there forced the Department of Agriculture's explorer to suspend operations and return home.

From the agricultural exploration work in Madagascar, inaugurated just before the close of the present fiscal year, the department hopes to secure seeds and other plant propagation material of a wide range of potentially promising rubber-producing plants for trial in this country.

Precautions Against Pests

The Bureau of Plant Industry is exercising every precaution to guard against the introduction and dissemination of new plant diseases, insects, and other pests. All its foreign-plant introductions are carefully inspected and subjected to fumigation or other protective treatment upon receipt in Washington. As a result of this practice, supplemented by the sanitary means and improved practices in operation at our plant-introduction gardens, in connection with the propagation, growing, handling, and testing of new plant immigrants, the bureau is able to distribute its foreign-plant introductions with the assurance that the precautionary methods employed have guarded against the introduction of any new plant pests or the dissemination of pests already established.

In many sections land brought into cultivation by irrigation has become unproductive after a few years. Large investments of capital and labor are required to provide irrigation water and to develop irrigated land. It is therefore essential that such land should be highly and continuously productive. Some irrigated lands are highly productive and others are not. If knowledge as to the reason for these differences is not available, it is obvious that the development of irrigated lands must continue to be a speculative enterprise. Here, perhaps, is the principal reason for the fact that credit for operations on irrigated land is relatively costly.

Agronomic work has been conducted by the bureau at field stations with a view to determining the factors responsible for the productivity of irrigated land. This work has yielded important practical results. It has shown that the chief hazards in irrigation farming, aside from those common to ordinary farming, may be grouped into three classes: The accumulation in the subsoil of excessive quantities of water, the accumulation in the soil of the root zone of excessive quantities of soluble salts, and changes in the physical condition of the soil by which it becomes impermeable to the movement of water and consequently unproductive. These three difficulties may occur together, but any one of them occurring alone eventually may cause disaster. Understanding of the nature and causes of these difficulties makes it possible to anticipate injury before it becomes serious.

Two Sources of Injury

Our investigators have found that the accumulation of soluble salts in the surplus zone, or root zone, to the point of injury to crop plants may come about in either of two ways. Where the subsoil is saturated with moisture so that the surplus soil is kept moist from below, continued evaporation results in concentrating the soil solution past the limit of tolerance of crop plants. A similar condition may result where the subsoil is not saturated. When irrigation water is used so sparingly that all the water applied is held within the root zone, to be absorbed by plants or lost by evaporation, the salts carried in solution in the irrigation water remain in the root zone and in time make the soil solution too concentrated.

Changes in the physical condition of the soil, in the direction of permeability, result from reactions that take place between the soil and the salts in the soil solution. When the salts in the soil solution are chiefly salts of sodium, the reaction with the soil is in the direction of replacing calcium from combination with the soil. The sodium passes into soil combination and the replaced calcium passes into solution, and accordingly may be more or less rapidly leached. Soil containing appreciable quantities of combined sodium, as a result of such replacement reactions, become dispersed and gelatinous when wet, do not absorb water readily, and become hard or "bake" upon drying.

As for the other principal cause of difficulty (the accumulation of injurious quantities of subsoil water) it has been found that this is often due to percolation losses from canals and ditches. It was formerly attributed chiefly to the excessive use of irrigation water by farmers. In any particular case the first need is to decide what is the chief source of the water causing the trouble. A correct diagnosis may point to preventive measures less expensive and more effective than drainage. Loss of productivity in irrigated soils is a difficulty better dealt with by prevention than by cure. Recent research work by this department throws a flood of light on how prevention may be accomplished.

Homesteads in Dry Regions

Maintenance of homesteads in the so-called dry-land regions is another subject to which the bureau has devoted considerable attention. It has been demonstrated that homes can be established and families maintained from the returns of fruits and vegetables on farms in the Great Plains area, which comprises more than 400,000 square miles. In this region agricultural difficulties resulting from the unusual climatic conditions prevailing are substantial, and progress must of necessity be slow. Patient scientific work, however, is discovering solutions to various problems.

Shelter-belt trees have been found to prevent soil blowing, often a serious problem. Protection afforded to crops by shelter belts, supplemented by proper cultural treatment of the soil, has proved very valuable. Years of experiment at the United States Northern Great Plains Field Station, Mandan, N. Dak., have produced shelter trees that can be grown successfully in the region, and the demand for such trees now exceeds the supply. As a result of this and similar work attractive farmsteads are beginning to dot the prairies in the

plains region. This is a favorable augury, for it is well known that any permanent agriculture must plant its roots around the farm home. Sufficient vegetables can be grown to support a family of five on a 1-acre plat in the dry-land region. With this fruit and vegetable output, and also with a cow or two, a litter of pigs, and a flock of poultry, a competent farm economy can be established.

Important investigations are under way to develop wheat varieties resistant to smut and rust. Stinking smut has always been a problem in wheat production. It is especially prevalent in the Pacific coast region and in recent years has been increasing east of the Rockies. To-day it is an important commercial problem in most of our wheat markets. As yet no smut-resistant variety of wheat has been demonstrated as suitable for general culture in the regions growing hard red spring, hard red winter, and soft red winter wheat. Until resistant strains suited to these areas are developed it will be necessary to continue seed treatment to prevent smut. In the last season all the smut-resistant varieties under experimental observation showed more or less smut infection, and the reason for this susceptibility is being sought.

Smut-Resistant Strains Developed

A number of strains comparatively resistant to stinking smut have, however, been developed. Some of these have been distributed to growers in the Pacific Northwest, where they are increasing in acreage. Other resistant strains have been developed but not distributed, either because they are not adapted to general culture or because seed is not yet available. The resistant strains that have been distributed have a limited adaptation and can be profitably grown only on a small part of the present wheat acreage of the country. Extensive cooperative breeding programs on hard spring wheats and durum wheats are under way with the State experiment stations, and several varieties resistant to leaf rust and more or less resistant to stem rust have become of commercial significance. These require adequate testing over the entire spring-wheat area. Commercial development of some promising resistant strains is probable within the near future.

One of the most striking recent discoveries of the Bureau of Plant Industry is the influence of pollen on the development of the fruit of the date palm. This discovery, which has been fully confirmed with every precaution to prevent error, has shown that different kinds of pollen yield different qualities of dates differing widely in important commercial attributes. Pollen from certain male trees causes the production of small seeds and small fruits that ripen early. Pollen from other trees causes the production of large seeds and large fruits that ripen late.

As the difference in time of ripening often amounts to several weeks, it is occasionally sufficient to decide whether the crop can be ripened properly, cured, and sold, or will be lost completely as the summer rains begin. All date palms must be pollinated artificially in order to cause them to produce fruit crops. Since it is as easy to use one kind of pollen as another, the bureau's discovery gives the date grower power to influence the time of ripening of his crop, and to a certain extent, the power also to influence the size of the fruit. These, of course, are matters of vital importance in successful commercial date growing.

In all probability the scientific importance of this discovery will be very great. It is, so far as is known, the first definitely proved instance of the effects of pollen on the development of fruit. Similar effects may be observed in plants other than the date palm, and studies of this character are under consideration. This is bound to be a subject of great scientific as well as of great practical importance.

Rubber-Production Possibilities

Investigation of rubber-production possibilities in the United States is under way on the basis of a recently developed principle or method of procedure. Attention is given first to the cultural character of the plants, so as to determine which species are best adapted for our conditions. Intensive investigation of special processes of extraction and utilization of rubber or of rubber by-products is then concentrated on the more promising species. This work is not restricted to the plants that have heretofore been considered as commercial sources of rubber, for the agricultural possibilities of a plant do not depend upon its abundance in the wild state.

It has been found that tropical rubber trees will grow to normal maturity and produce seeds in Florida. This is indicated by the behavior of all the principal types. Accordingly, experiments in selection, adaptation, and cultural behavior are in progress. Tolerance to frost and cold weather in southern Florida has been demonstrated for the Hevea or Para rubber tree of Brazil, and for several other tropical rubber trees. This has been shown through the repeated cold spells of the last few years, and particularly in the winter of 1927-28 when a minimum temperature of 28° F. was experienced. Study of seedling adaptations of the Hevea rubber tree indicates a wide range of possible cultivation, not limited to the equatorial belt of South America but including the West Indies and Central America. In California the cultivation of guayule is being increased to the scale of commercial production by a private company, and the department is studying other native rubber plants.

Constructive changes in the cotton industry are projected by the department, their practicability having been demonstrated. These improvements require the cooperation of entire communities of cotton growers. Popular understanding and leadership must, therefore, be developed before substantial progress can be expected. Interest in the subject has been aroused, however, and many demands are made for assistance in putting improved methods in operation. Community cooperation makes it possible to change the basis of production from the usual conditions of mixed and mongrelized seed stocks to regular supplies of pure seed. Thus all the farmers in an organized community or district can produce fiber of the same character, and with production thus unified the way is open for utilization of improved varieties and methods.

Cotton in Atlantic Coast Section

In the Atlantic coast section the outlook for continued cotton production seems to lie in the possibility of a return to longer staples, either sea-island or long-staple upland varieties. In recent years short-staple upland varieties have replaced the former produc-

tion of sea-island cotton in this region. This replacement is perhaps only a temporary expedient. A return to long-staple cotton may be feasible if communities can unite on a single variety. It is difficult, however, to avoid weevil injury to the long staples if earlier short-staple varieties are to continue to be grown in the same district.

Many additional problems have been created for the cotton industry by the recent development of an extensive new area of production in the plateau region of northwestern Texas, where the crop can be grown more cheaply than in many of the older producing districts. This extension involves increased competition and has already seriously threatened production in some of the more humid districts of the former Cotton Belt. In other parts of the old South the outlook will depend largely on the extent to which better facilities and improved methods are employed. In districts where conditions favor the production of fiber of premium quality and length of staple, the prospect is not discouraging. The best assurance of a favorable market status for any community of cotton growers is to be found in the regular production of fiber of good quality. Present conditions tend to impress that principle on the minds of the growers and to promote compliance with it. In the Texas plateau region a limited rainfall involves hazard and difficulty in production, but the rainfall requirement is less than at lower altitudes and the boll weevil is not present. Unquestionably, therefore, we may expect significant changes in the cotton-growing industry.

Great benefit to the citrus industry has resulted from work done by the department in bud selection for nursery propagation. This work, which is based upon tree-performance records, promotes the elimination of nonproductive and nonpaying trees through top-working them with productive strains of high quality. It also promotes the planting of new orchards with trees propagated only from highly productive parent stock. Total production as well as quality has thus been increased materially, with a relatively small increase in the acreage devoted to citrus fruits. It is conservative to estimate that several millions of dollars have been contributed to the citrus industry of California by the elimination of nonproductive trees through the principles of fruit improvement by bud selection. Some important conclusions have been developed from bud-selection research. In the early stages of the work propagations were made from various strains. The progeny trees, planted in orchard form, have now been producing fruit long enough to justify the conclusion that in tree and fruiting characteristics they reproduce the qualities of the parent stock with remarkable consistency.

Problem of Arsenical Sprays

In recent years the presence of arsenical spray residues on fruit has created a problem in both export and domestic markets. The necessity of removing such residues, so that the quantity remaining will be within a specified tolerance, has been urgently projected into the business of handling and marketing apples and pears. It has been felt particularly with respect to fruits grown in arid or semi-arid regions. In such regions larger spray residues are likely to remain on fruit than in humid sections, where more or less frequent rains tend to wash them off. Wiping the fruit, either mechanically or by hand, has proved an insufficient remedy. It has therefore been

necessary to resort to washing with dilute solutions of either hydrochloric acid or alkalies, and fairly effective methods for so doing have been developed.

Many thousands of strawberry seedlings resulting from hand-made crosses have been under careful observation and several promising seedlings have been placed for testing with experiment stations, nurserymen, and others to determine their range of adaptability. A larger selection has been reserved for further study. As a result of these experiments, up to the present time four varieties of strawberries have been selected as definitely superior to the commercial varieties now used for making preserves and crushed fruit. Some selections have also shown superior merit in color, firmness, productivity, and high flavor. About 11,000 raspberry seedlings, likewise the result of hand-made crosses, have been under observation. The raspberry-breeding work is relatively less advanced than the strawberry work; one hybrid raspberry variety, however, has been selected as superior for the canning trade. These selections are being propagated with the object of giving them wide commercial tests. Canners, preservers, and commercial growers believe that with both these fruits substantial progress has been made.

Phony Disease of Peaches

Diligent study has not yet disclosed the nature of the phony disease of peaches, which is prevalent in Georgia and is increasing in severity. At its present rate of progress this disease may reach other States in a few years. All experiments to control it have yielded astonishingly negative results. The trouble stands out distinctly as the least understood of all fruit diseases, if not of all plant diseases. A tree once affected remains diseased always. No beneficial effect has yet been observed from the use of fertilizers, soil treatment, or other attempted remedial measures. This fact suggests that the disease is not physiological or nutritional. Attempts to transmit the disease by the injection of the juice expressed from various parts of phony trees have failed. Nor is the disease transmitted when buds or scions from phony trees are budded on nursery trees or on normal peach trees. Growth following such budding is invariably normal. On the other hand, when normal buds or scions are budded on phony roots the resulting growth is always typical of the disease.

The phony disease has been found growing naturally only in the peach tree. It attacks seedling trees and trees of all commercial varieties grown in Georgia. It has never been observed in wild plums, although wild plums are abundant near commercial peach orchards. It seems not impossible, however, that the disease may attack fruits closely related to the peach if it is introduced into districts where such fruits are grown. A small percentage of trees in badly diseased orchards appear to be resistant to the phony disease. This behavior suggests the possibility of selecting resistant stocks. Vigorous effort to control the trouble is urgently necessary. Although the communicability of the phony disease has not been definitely established, it has already traveled 200 miles from Marshallville, Ga., where it was first observed. It has increased from commercially unimportant numbers 30 years ago to a degree that threatens a great industry.

Results of Control Efforts

Recent attempts to control the virus of mosaic diseases, which cause very destructive losses on a wide variety of crops, including beans, tomatoes, potatoes, sugar beets and sugar cane, corn, wheat, and tobacco, have given a measure of success. Promising results have been obtained in efforts to develop resistant varieties, and by the roguing out of diseased specimens of susceptible crops in the early stage of the growing season. Infection tests have been carried on with mild mosaic, rosette mosaic, leaf roll, and spindle tuber on some of the most important commercial varieties of potatoes. None of the varieties or seedlings tested is immune to all of these diseases. Nevertheless, considerable variation in susceptibility has been observed, especially in the case of mild mosaic and spindle tuber. The Irish Cobbler variety has not manifested the mild-mosaic symptoms characteristic of the Green Mountain variety. Similar responses to mild mosaic have been noted with some seedlings. Field inspection during five seasons, combined with roguing the diseased plants from tuber-unit isolated seed plots, have eliminated certain virus diseases and retained other types within relatively low percentages under northern Maine conditions. Disease-free potatoes propagated in tuber-unit plots surrounded by forests have been maintained free from disease for several seasons. This indicates that no infection was contracted from noncultivated plants. Certain commercial growers, by conducting isolated field or seed plots, have developed and maintained potatoes sufficiently free from the virus diseases to qualify for certification of seed stocks.

Valuable results have been obtained in a study of the winter cover-crop problem in the South. In most sections of the South the use of winter legumes should extend the grazing season so that cattle might be kept outdoors the year around. An outstanding need is an adequate seed supply of hairy vetch, *Monantha* vetch, Austrian winter pea, and bur clovers. Several years ago a source of winter-pea seed was discovered in Europe, and a supply was imported under the name "Austrian winter pea." In seven years of continuous testing in Georgia this winter pea has never failed to make a good growth. It is now grown on small acreages over most of Georgia and to a less extent in Alabama and South Carolina. It will withstand low temperatures as well as hairy vetch, and is ready to plow under earlier in the spring. This is of great importance, because the foundation of all permanent improvement in agriculture in the South consists in the adoption of a sound system of rotations involving the use of legumes which either by means of their residues or by means of the entire crop turned under add nitrogen and organic matter to the soil.

New Sugar-Beet Varieties

Encouraging progress has been made in the development of sugar-beet varieties resistant to the curly-top disease. It is expected that it will be possible, after a few more trials, to put several of the newly developed strains on the market. In experimental tests they have shown decided superiority to the commercial varieties, not only in resistance to curly top but in sugar production. It has been dis-

covered also that partial shading offers an important means of controlling the disease, which is transmitted by the sugar-beet leaf hopper. This disease has assumed increased importance from the discovery that it may also attack tomatoes, beans, summer squash, peppers, horse-radish, and spinach. Relationship of light to the control of the disease will, it is hoped, develop further indirect methods for eliminating injury.

New varieties of sugar cane introduced into the United States in recent years have proved of great value. The cultivation of these varieties has rehabilitated the sugar-cane industry in Louisiana. An imperative need exists, however, for the breeding and development of varieties more resistant to disease and more specifically adapted to culture in the United States. Accordingly, the department's plant explorers are searching for promising strains in New Guinea and other islands of Melanesia, where the sugar-cane plant has reproduced itself by seed through countless generations. Under such conditions it is reasonable to expect that natural selection will have eliminated seedlings susceptible to mosaic and similar destructive diseases. Sugar cane indigenous to this region belongs to the thick-stemmed or "noble" type, which planters everywhere esteem. It has been found that the disease-resistant varieties that have been introduced improve in vigor and in resistant qualities when crossed with primitive types. Although this proceeding gives smaller and more slender hybrid varieties, the superior performance of such varieties under present tests makes them acceptable to planters. It is hoped, however, that high-yielding, thick-stemmed varieties immune to disease may be found in Melanesia or may be developed by breeding from varieties obtained there.

Influencing Plant Ripening

Some years ago an extraordinarily important discovery was made in the Bureau of Plant Industry relating to the influence of the length of day on plant growth, which opened an almost unlimited field of research. It was demonstrated that the change in the length of day which comes with changes in the seasons and in latitudes controls or affects features of plant behavior of fundamental importance to agriculture. Subsequent investigation has revealed something about the significance of length of day under practical growing conditions. Information has been sought which may indicate how the time of flowering and fruiting of certain types of plants and their adaptability to different latitudes can be favorably influenced.

Clearly this discovery opens up new possibilities in the control of plant life. An example of its significance in the case of soy beans has been very strikingly furnished in the vicinity of Washington, D. C. In this locality the Biloxi variety regularly flowers in the early fall rather than in midsummer, because the summer days are too long. On the other hand, the Peking variety regularly flowers late in July because it responds to a somewhat longer day. But it is prevented from flowering by the longest days of early summer. In the case of both varieties the time of flowering is delayed by a higher latitude and hastened by a lower latitude. It has been found, on the other hand, that some of the very late varieties are not particularly sensitive to changes in the length of day. In the case of these strains

the length of the vegetative period is not greatly affected by the date of planting. More effective use of the different varieties may be expected from the clearer understanding of these differences in behavior.

ECONOMIC SERVICES AND RESEARCH

In the last few years the work of the Bureau of Agricultural Economics has been greatly enlarged, and at the same time farmers and the public generally have become better acquainted with its value. Demands are constantly made on the bureau for new services and for the extension of services already well established. The inspection of fruits and vegetables, which not many years ago covered only a few thousand cars at terminal markets, last year was applied to 243,262 cars at shipping and receiving points. This was an increase of approximately 17,000 cars over the number inspected the preceding year and more than 50 per cent over the number inspected four years ago. An increase took place also in the inspection of dairy and poultry products, hay, grain, and other commodities. Much commodity-inspection work was done for other departments of the Federal Government. Meat grading and stamping, a service begun as an experiment, proved highly successful and was put on a fee basis. By this service beef carcasses are stamped so that the grade appears on retail cuts. A seed verification service has been inaugurated. This requires the maintenance of records and accounts by seed dealers under the supervision of the department. As yet the service is limited to alfalfa seed, a product whose point of origin is very important. Eventually the service will probably be extended to include other seeds. The service is conducted on a voluntary basis by means of cooperative agreements between seed dealers and the department. A great increase has taken place in the demand for copies of the official cotton standards which are prepared and sold by the bureau.

The scope of standardization has been widened by the use of standardized grades as a basis for price quotations in the bureau's market news services. Shipping and receiving point inspection likewise promotes standardization, since it is conducted on the basis of official grades. Standardization facilitates the interpretation as well as the improvement of market conditions. It is easier to analyze supply and demand information when it comes from many sources in a common language, so to speak. A recent development in standardization was the enactment at the last session of Congress of a measure authorizing the Secretary of Agriculture to use certain funds for studies covering all phases of the marketing of wool, as a step toward the establishment of wool standards. This work is under way.

Much of the bureau's work involves the administration of various Federal laws. In this task the officials charged with administrative functions receive general cooperation and support from the agricultural and trade interests particularly concerned. As a result the regulatory work has become largely a service function. The licensing and supervision of warehouses under the United States warehouse act, for example, insures the safe storage of the farmer's crop until

it can be marketed advantageously and at the same time makes the warehouse receipt better collateral for bank loans. Thus the farmer's business is facilitated, while at the same time the stabilization of markets is promoted. Further progress under the United States warehouse act was taken last year when tentative standards were drafted for canned vegetables destined for storage in federally licensed warehouses. Regulations were also promulgated for the storage of cold-pack fruit.

Demand Growing for Market News

Crop and livestock information is in steadily increasing demand. In the last fiscal year the call for statistical information was practically double that of the previous year, with farmers particularly showing increased interest in economic information. The department's crop and livestock reporting service now issues regular reports on 80 field crops and 10 livestock commodities. In the last few years the information gathered has gained tremendously in variety and comprehensiveness. I referred last year and the year before to recent improvements made in the technic of crop reporting, and this useful progress continues. Crop statistics for past years have been reviewed, the revision in the case of livestock numbers and values going back to 1900. Facts are now gathered also as to the disposition of crops. Acreage statistics are being revised in the light of recent changes in the sources of information and in the methods of obtaining data.

Among the more recent developments in the crop-reporting field is the publication of monthly reports on the production of eggs and of milk on farms whose operators cooperate with the crop-reporting service. These reports form the basis of monthly indexes of egg production and milk production. The country is constantly demanding more information on marketing as well as on production. Accordingly, the bureau's market news service endeavors to publish the desired information in the most useful form. Its leased-wire telegraph service, connecting many of the principal markets, is the mainstay of the service. Branch offices serve as bases for gathering and transmitting information and also for distributing data locally required. Additional distribution is given to the bureau's economic information by radio, telephone, and commercial telegraph, as well as by mimeographed bulletins and press releases.

Underlying the service and regulatory work of the bureau is the research work of the entire department. Much of the work done by other bureaus is utilized by the Bureau of Agricultural Economics, and a high degree of cooperation between the bureau's economists and the other scientific workers of the department has been brought about. In this way duplication of effort has been reduced and related studies have been coordinated. Problems presenting a complex intermixture of economic, agronomic, biological, or chemical factors are thus brought more easily within the scope of scientific investigation. Cooperation in scientific inquiries is not limited to divisions of the Department of Agriculture. It exists among all the departments of the Government. Important information is constantly made available to the Bureau of Agricultural Economics by

research workers in the Department of Commerce, the Department of the Interior, the Post Office Department, and the State, Army, Navy, and Labor Departments. Thus aided the bureau has won international recognition as the leading organization in its field.

Farm-Management Work Reorganized

The bureau's farm-management work has been reorganized so as to give the most practical assistance possible to farmers in solving the question of what to produce and how to produce it so as to obtain the greatest profit. All data available in the bureau, such as information on prospective market requirements and prices, production trends in competing regions, and production costs are interpreted in the light of conditions governing successful farming in particular regions in such a way as to assist individual farmers in determining sound production programs for their farms. This work is carried on in practically all cases in cooperation with State and local agencies. A more profitable system of farming on tobacco farms of south-central Virginia is being brought about through the work of this department and the Virginia Polytechnic Institute. Farmers are reorganizing their farms so that tobacco plays a less important part in their income. Poultry, dairy, and hay enterprises have been expanded and in general only the better fields planted to tobacco. The same type of work is carried on in many other sections.

Special studies are under way in the area affected by the corn borer to determine the most economical methods of controlling the pest and the adjustment it will necessitate in farm activities. The results of these studies have been published, and should assist farmers in adopting methods which will be successful in meeting the emergency. A new project, known as farm budgeting, has been inaugurated in several States under which definite farm plans are worked out with farmers who agree to put them into operation. These plans are the result of farm budgets for different systems carefully worked out and compared. The farmers keep accounts during the year and the results obtained are compared with the results that might have been obtained with other systems as shown by the budget statements. Much progress has been made in promoting the use of records and accounts of farm activities.

Assistance is being given American farmers through the work of the foreign offices of the department. The department's specialists abroad explain to foreign buyers the standards for American farm products, and advise American producers and shippers with regard to foreign marketing conditions. Much information is received in the department from its foreign offices, from the consular service, from commercial attachés, and from the International Institute of Agriculture, which is summarized and published. This information is supplemented by special reports on the economic situation in foreign countries as it affects the demand for American agricultural products. Surveys are made of production and trends of production in foreign countries for the purpose of informing American producers with regard to the competition they must expect. The information received is necessary for consideration in connection with statistics covering the situation in the United States.

Foreign competition in either the domestic or the foreign market or in both directly affects about 90 per cent of the agricultural products of the United States which enter into market channels. In a normal season, more than 50 per cent of the cotton crop, 30 per cent of the tobacco crop, and 20 per cent of the wheat crop are exported. About 34 per cent of the average production of lard and 8 per cent of other hog products are exported annually. Knowledge of production outside of the United States and also of foreign market conditions is essential in planning the production and marketing of these products. Knowledge of foreign production and markets is equally necessary in the case of products of less importance. In some cases, indeed, such knowledge is more important than knowledge of the situation in the United States.

Many serious marketing difficulties have their origin in irregularities of production, resulting from variations in acreage, yields, or both. Farmers have comparatively little control over yields each year, but acreage is more amenable to adjustment. Studies have shown in the case of some crops that annual variations in acreage are an important factor in variations in production. In other words, farmers are not entirely without power to influence the volume of their output. Too often, however, high prices stimulate increased planting or breeding without due consideration of market prospects. Thus production becomes unstable and unbalanced, and the farming industry suffers from extreme price fluctuations. It is to the interest not only of the farmer but of the entire community that agriculture should not be periodically depressed by overproduction and low prices.

As a means of promoting orderly production and orderly marketing, the Bureau of Agricultural Economics gathers information to show the probable trend of production and demand. Research of this type has been in progress for six years. Bulletins have been published dealing with factors affecting the prices of hogs, oats, and cotton; the prices of lambs, wheat, wool, and apples have been discussed in special articles. In these price studies the first step is to discover and measure the influence of the principal price-determining factors. Then the influence of these factors is traced by comparisons with prices reconstructed over a series of past years. In this way the past is studied to throw light on the future. Forecasts of supply and demand thus obtained have been about 90 per cent accurate.

Timely forecasts issued with due caution help farmers to decide what to produce and when to sell their products. Analysis of the past relation of price to supply and demand conditions discloses the value of crops on the basis of current supply and demand conditions, and thus gives farmers an invaluable guide both in marketing and in future production. On the supply side, information is regularly furnished by crop forecasts. Information about demand is less abundant and exact, but is constantly growing in volume and reliability. Each month the Bureau of Agricultural Economics issues a price-situation statement in which current market conditions are examined and supply and demand prospects indicated.

Five years ago the department began issuing outlook reports annually as an aid to farmers in adjusting their production. Simultaneously a system of reports was inaugurated giving information as

to the intentions of farmers to plant crops or to breed and feed animals. The intentions-to-plant reports inform individual farmers what the farmers of the country as a whole are planning. Such information, when furnished in time to influence planting or breeding, may help greatly in forestalling maladjustments in production.

Commercial agencies often are able to supply themselves with information on supply and demand conditions affecting the prices of products handled by them, but individual farmers are unable to do so because of the complexity of the problem. Timely information of this character is essential to balanced production and orderly marketing, and is helpful not only to farmers but also to the general public. Therefore it is a proper function of governmental agencies to compile and publish information of this character as a guide to private effort.

It is worth noting that the major farm relief proposals discussed within the past few years were predicated on price analysis and market forecasting. In fact, the measure which attracted most attention would have demanded considerably more price analysis than the department is at present in a position to furnish. This is a recognition of the obvious truth that modern agriculture can not prosper without economic information as a guide to production and marketing.

Blind competition leads inevitably to disastrous extremes in output, and therefore to destructive price fluctuations. When the department's outlook and intentions-to-plant reports are better understood and more generally used by farmers, an important step will have been taken toward the stabilization of agriculture. I have mentioned the fact that accurate forecasts of excessive potato production this year failed to influence planting materially. Similar examples might be cited in regard to other crops. Each year, however, farmers become more aware of the utility of economic information and better skilled in applying it to their business.

Extension of Economic Information

Attention is given by the department and by the cooperative extension agencies of the various States to extension activities designed to furnish more complete economic information to farmers. Research results are not realized in full until they are communicated to farmers through extension activities. Farmers are relying more and more on the extension agencies for economic counsel. It is imperative to provide them with essential facts about farm management and about the proper adjustment of farm enterprises to probable market requirements. This can be done without giving less attention to the technical problems of production. Knowledge gained by the study of prices and price trends becomes of practical value to agriculture only when it influences the production plans of individual farmers or groups of farmers.

Farmers highly value extension work of an economic character. This is shown by the widespread interest taken in the department's outlook work and in that of the cooperative State agencies. In some districts farmers have taken the lead in late years in calling conferences to discuss economic questions. Interest in economic questions is not confined to prices and market prospects. It includes also such

broader aspects of the agricultural problems as are involved in the taxation of land, reclamation and reforestation, and other land problems. Facts gathered by research workers on these problems gain increased practical significance when presented to farmers through extension agencies or in other ways. Constructive and permanent means of improving agricultural conditions depend in the last resort on an appreciation by farmers and by the general public of the complex nature of agricultural problems. Economic extension work is among the most powerful influences in producing this frame of mind.

Crop-Insurance Studies

The uncontrolled hazards of agriculture are a serious problem. Whatever the farmer may do to safeguard his production, the dangers of loss from storm and flood are ever present. In industry, systems of insurance have been developed to provide safeguards against unexpected losses. Agriculture needs similar protection in crop and livestock insurance. Our experience with crop insurance is limited, and research is required to show the way toward better methods. Crop insurance has received the consideration of Congress in response to a resolution of the Senate. A report on the problem is being prepared.

CHEMISTRY AND SOILS WORK

In 1927 the department's Bureau of Chemistry, its Bureau of Soils, and its Fixed Nitrogen Research Laboratory were consolidated in a single research unit called the Bureau of Chemistry and Soils. I wish to refer in this report to work done during the entire period of my administration. Some of the accomplishments I am about to mention were launched or completed before the above-mentioned consolidation was effected. It will be convenient, however, to speak of them as activities of the Bureau of Chemistry and Soils since the department units concerned are now merged therein. The record is singularly rich in cash results achieved for farmers.

A typical example is a service rendered to some 400,000 farmers who produce cane and sorghum sirups. These commodities are annually produced to the amount of about 80,000,000 gallons. It has been difficult to find a market for these products, owing to their lack of uniformity and to the poor keeping quality of some sirups put up in retail packages. A remedy for the trouble has been found in a method of blending, standardizing, and treating sirup, so as to produce an article of standard and sustained character. This method, the result of prolonged research in the Bureau of Chemistry and Soils, will probably permit the establishment of cooperative blending and canning plants. Another recent achievement of the bureau which promises substantial benefit to cane-sugar producers is a method of making a creamed sugar residue which has been named "cane cream," and put on the market by one large producer in Louisiana.

Instances of similar contributions by the Bureau of Chemistry and Soils to agricultural welfare could be multiplied indefinitely. Its research work has shown how losses in refining cottonseed oil, which

amount to some 7 or 8 per cent of the crop, may be materially reduced. As our vegetable-oil crop has an average annual value of about \$500,000,000, this discovery promises to effect large savings. Studies are under way which may develop means of reducing losses in the curing of hides and tanning materials and in other branches of the leather-goods industry. Such losses are estimated to exceed \$250,000,000 annually. The turpentine and rosin industry has been benefited by improved stills, devised and patented in the department, which are expected to save producers \$1,000,000 annually and to yield better and cleaner turpentine and rosin. Processes have been worked out that triple the life of the shade cloth used by tobacco growers in their plant beds, their annual bill for which exceeds \$2,000,000.

Insecticides and Fungicides Improved

Much has been done to improve and cheapen insecticides and fungicides. About the only available material which can be used as a contact insecticide in the fight against sucking insects is nicotine. But nicotine costs as much as \$3 a pound. In view of the quantity necessary in the war on insect pests, this price often makes its use impracticable. In the last few years the Bureau of Chemistry and Soils has synthesized and produced two new chemical compounds obtained as a by-product from the manufacture of illuminating gas. These compounds have insecticidal properties nearly as great as those of nicotine and can be produced, it is believed, at a cost of only a few cents a pound. Their appearance in chemical markets is expected shortly.

Still another extremely important recent discovery by the bureau is that of a new fumigant which may be substituted for the highly inflammable carbon bisulphide and the hazardous hydrocyanic acid. This fumigant, ethylene dichloride-carbon tetrachloride mixture, although discovered only within the last two years, is now produced in large commercial quantities.

In the fight against the boll weevil the odorous principle of the cotton plant has been studied. This principle, which is believed to furnish the attraction to the weevil, has been isolated and the compound can probably be made synthetically. Here is a possible means of furnishing bait for boll weevils which may have considerable importance in the fight against the pest.

With a small appropriation provided by Congress, a campaign was begun in 1927 to reduce the loss from farm fires, which amounts annually to more than \$150,000,000, in addition to the loss of about 3,500 lives. Although the work has barely started, it has already indicated the likelihood that within the next few years the farm fire loss may be reduced as much as 10 per cent. Dust explosions as a source of loss in many localities have been materially reduced by methods developed by the Bureau of Chemistry and Soils. Equipment developed in the bureau has been widely adopted and methods of threshing and grain handling have been put in effect. It has been estimated, indeed, that savings thus made may in a single year equal the entire cost of the bureau's research work.

Soil Survey Extended

Soil investigations and particularly the department's soil survey have proved extremely valuable in recent years. Field parties have mapped 21,838 square miles in detail and have made reconnaissance surveys of more than 17,000 square miles during the past fiscal year. These surveys, added to the area previously covered, give a grand total of approximately 754,000 square miles of detailed surveys and 598,000 square miles of reconnaissance work. Knowledge of our soil resources has thus been made greater than that of any other country. Indeed, it may exceed that of all other countries combined. From field studies of the major groups of soils in the United States and Central and South America much information has been gained that should aid in solving fundamental problems of soil classification.

In recent years the department's soil-survey work has been utilized by other agencies of the Government. A typical example was the appointment recently by the Secretary of the Interior of a fact-finding committee to investigate the present status and determine the future policies of the Reclamation Service. This committee took into consideration the results of soil-survey work by the Department of Agriculture on reclamation projects completed and pending. It was so strongly impressed by the value of soil surveys that it recommended that no additional engineering work should be done on old or new reclamation projects until the soils included had been studied and their suitability for agriculture determined. Accordingly the department is now frequently called on to make detailed soil surveys of areas within contemplated reclamation and colonization districts.

In like manner it is requested by the Indian Service to examine agricultural-development projects before engineering expense is incurred. The Department of Commerce has obtained from the Department of Agriculture information about the soils of American countries to the south, with particular reference to rubber production in the West Indies and Central America. Within the department the Bureau of Public Roads makes use of the soil survey in its highway-engineering work.

In growing soil-improving crops such as clover, alfalfa, and soy beans, soil and seed inoculation with nitrogen-fixing bacteria is desirable. This has stimulated the production, by both public and private agencies, of cultures for inoculation purposes. The department, while encouraging such work, inspects cultures offered for sale to farmers, a service rendered necessary by the fact that soil "cure-alls" and other nostrums are sometimes sold. In general the quality of the cultures offered is good. Occasionally, however, brands fail to show the merits claimed for them and steps are then taken to prevent possible purchase. Studies now in progress may reveal means whereby some of the little-known members of the invisible soil population may be made more efficient by selection, by adjustment of crops, or by addition of fertilizers and soil amendments. For the present, however, the nodule bacteria of legumes remain the only ones that can be satisfactorily utilized in trade.

Developments in Fertilizer Industry

Important developments have lately taken place in the fertilizer industry. The Bureau of Chemistry and Soils has contributed materially to the progress effected. Much research work has been done to increase the supply of fertilizer ingredients from our own great natural resources. Studies have also been conducted to improve the technic of fertilizer production and to cheapen and improve the finished product. To-day the fertilizer industry is in a rapid transition to a chemical basis, largely as a result of the development of methods for fixing atmospheric nitrogen.

The department's fixed-nitrogen laboratory has made noteworthy contributions to the science of fertilizer synthesis. It has established and interpreted some of the fundamental chemical, physical, and engineering data involved. The information has been put at the disposal of American fixed-nitrogen plants and men trained in the department's laboratory have been in constant demand by the fixed-nitrogen industry. Some idea of the progress made can be gained from the fact that the production of fixed nitrogen in the United States now exceeds 36,000 tons a year, compared with only 6,000 tons in 1923, and plants now under construction will double the present output. In comparison with Germany's output of fixed nitrogen, however, ours is small. Germany's annual production of 660,000 tons indicates the need for energetic development of the American industry.

American farmers are, of course, still heavily dependent on foreign materials for nitrates and potash. Exploitation by foreign agencies not subject to American control can only be terminated by the development of American production, at least to the point where the prices of these essential commodities will be dictated at home and not abroad. Research in the Bureau of Chemistry and Soils is conducted to assist in developing an American potash industry, the necessary raw materials of which exist here in abundance. Gratifying progress is being made. Four years ago our annual production was 20,000 tons actual potash (K_2O). Last year the output amounted to 44,000 tons.

Concentrated Fertilizer Mixtures

Another important branch of the department's fertilizer studies indicates the economy of concentrated fertilizer mixtures. Fertilizers should be marketed in a high state of concentration. Four or five years ago commercial fertilizer mixtures seldom contained more than 15 per cent plant food. Sale of such mixtures entailed the sacking, transportation, and handling of 85 per cent of materials from which the farmer obtained little, if any, benefit. The freight bill paid annually by the American farmer for the delivery of the 7,000,000 tons of fertilizer which he purchases amounts to approximately \$20,000,000. If the concentration of fertilizers should be increased twofold, the freight bill would be cut in two and the annual bill of \$12,000,000 paid for sacks would likewise be halved.

Research in the bureau has shown that higher concentration is practicable. Methods have been devised whereby the diluents found in fertilizer ingredients as formerly prepared may be largely elimi-

nated. Salts containing two and even three elements of plant food and representing a concentration as high as 85 per cent have been developed as a substitute for salts containing only one plant-food element. The fitness of these materials both for the fertilizer trade and in the field has been demonstrated. As a result, fertilizer mixtures containing as high as 60 per cent plant food are now being successfully marketed at a lower price and a greater profit. Means of utilizing American raw materials of nitrogen, phosphate, and potash in manufacturing processes have been demonstrated and opportunities have been pointed out for the development of additional resources.

These results indicate the value of chemistry to agriculture. Nevertheless, there is need for a wider application of chemical research to agriculture, for the problems awaiting solution are complex. Our knowledge of the chemistry of cellulose, lignin, starch, proteins, vitamins, and other constituents of crops and animals is very incomplete. Comparatively little is known as yet about some of the common processes of animal life, such as the production of milk in the lacteal gland. Operations of plant and animal life are chemical processes upon the control and stimulation of which agriculture is coming increasingly to depend. Every farm is a chemical factory. Agricultural chemistry treats of the composition of soils, crops, and farm animals, and of the mutual chemical relations of these in so far as they concern the production of food and fibers. Its contributions to human welfare in the past, great though they have been, are undoubtedly little more than a hint of what will be achieved in the future.

Recently the Bureau of Chemistry and Soils sent a questionnaire to agricultural chemists asking what they considered the 12 most important contributions made by chemical research to national prosperity. The replies indicated a belief that the work leading up to the passage of the Federal food and drugs act, the development of accurate methods for analyzing agricultural products, food studies made possible by the use of the respiration calorimeter, research into the chemical composition, properties, and nutritive values of various crops, and the experimental use of lime to correct the sterility of acid soils stand in the forefront of the chemical services most highly valued. Other highly regarded technical developments are: Tests of fertilizers for farm crops, studies of vitamins, reclamation of alkali soils, development of the cane and beet sugar industries, investigations of the chemistry of soils, and work on the utilization of wastes and by-products in agriculture.

Prevention of Spoilage

Research by the Bureau of Chemistry and Soils is of value to farmers not merely in facilitating their production but in enabling them to prevent their products from spoiling. Moreover, agricultural marketing is becoming more and more dependent on the application of chemistry to the demands of popular taste. Markets for particular varieties of fruits and vegetables have been widened by chemical analyses such as those used in tests in the breeding of new strains rich in sugars, starches, acids, or essential oils. Chemical tests determine when fruits are ready to pick. The ripe orange

with a green skin can be colored without injury to its food properties by exposing it to ethylene gas. Scientific tests of the maturity of fruits have saved millions to horticulturists by enabling them to pick their crops at the most advantageous time. Some farming industries like fruit and dairy enterprises, when sufficiently organized, find it profitable to employ agricultural chemists just as do many highly capitalized manufacturing industries. An indication of the part played by chemistry in agriculture is the fact that no fewer than one-fifth of the chemists listed in American Men of Science are engaged in work of an agricultural-chemical nature.

RESEARCH IN DAIRYING

Research conducted by the department's Bureau of Dairy Industry is throwing invaluable light on many practical problems. An example is its work on the mineral constituents of a ration, particularly calcium and phosphorus, which shows their importance in maintaining a normal milk flow and probably also in bringing about successful reproduction. The bureau has demonstrated that a large milk yield can not be kept up without drawing on the reserve mineral supply in the animal's skeleton if calcium and phosphorus are not available in the feed. These minerals are much more readily available in properly cured legume hay, particularly alfalfa, than in the inorganic form. The practical significance of these facts is obvious.

Important facts have also been learned recently about the cow's udder. It had been generally believed that the milk-storing capacity of the cow's udder is not more than half a pint to each quarter, and that the greater part of the milk obtained at milking is secreted during the milking process. That this is incorrect was demonstrated by slaughtering cows just previous to the usual milking time. The udders were amputated and the milk drawn. In one experiment the quantity obtained averaged 61.1 per cent of the normal yield by the same cows. In another test the quantity obtained was 76 per cent of that given by the cows when alive. It was shown that milk secretion is largely a continuous process and that the capacity of the secretory system is much greater than had been supposed. This knowledge should help to lay a more scientific foundation for the selection of dairy cattle.

The sterility of cattle, or their failure to reproduce, is one of the greatest sources of loss to the dairy industry. Experiments by the bureau have shown that some forms of sterility in cows can be overcome by feeding sprouted oats. Sprouted grains, together with regular exercise, are effective also in prolonging the active service of valuable sires. Other experiments show that when roughages of the proper quality are available, cows of more than average producing capacity obtain sufficient nutrients from a ration consisting entirely of roughage. Cows with a producing capacity considerably above the average utilize grain profitably when fed at the rate of 1 pound to each 6 pounds of milk produced per day. They can not do so, however, when fed grain at the rate of 1 pound to each 3 pounds of milk produced.

Breeding projects undertaken by the bureau continue with favorable results. Bulls are provided from its experimental breeding herds for other Federal institutional herds and for State universities and

agricultural colleges. Two daughters of two of these bulls, one in the herd of the University of California and the other in the herd of the New Jersey Agricultural College, made world's records for their respective age classes last year.

Records Prove Value of Work

Some 200 young bulls are used on the herds of farmers in the vicinity of the bureau's experimental herds, chiefly for the purpose of determining their hereditary make-up for milk and butterfat producing capacity. In the vicinity of the experiment station at Huntley, Mont., 94 daughters of the bureau's bulls have completed a year's production record. This shows an increase per cow per year of 77.4 pounds of butterfat over the record of their dams, when both records are computed to a mature basis. The increased fat production had a local value of not less than \$34.06 per cow per year. The farmers living near the Huntley station herd have some 425 heifers sired by the bureau's bulls. If the increased production shown by the 94 already mentioned is maintained by the other 331 heifers, the annual value of the increased output will aggregate some \$14,475. The bulls found to have an inheritance for a high level of production will be used in the bureau's experimental herds or in the herds of cooperating agricultural colleges.

That the average production of dairy cows in the United States might be greatly increased is a matter of common observation. The average dairy cow produces about 4,500 pounds of milk and 180 pounds of butterfat a year. Contrast this showing with the performance of the cows in dairy herd-improvement associations. Records of the production of such cows are regularly tabulated by the Bureau of Dairy Industry on the basis of information representing dairy herd-improvement associations in 43 States. In 1927 the average production of cows owned by members of these associations was 7,410 pounds of milk and 293 pounds of butterfat. This showing is considerably greater than that made by the dairy herd-improvement associations in 1920. In that year the average production of association cows was only 5,989 pounds of milk and 247 pounds of butterfat. Each year since 1920 has seen a gain in the average production. The Bureau of Dairy Industry cooperates with a majority of the States in the dairy herd-improvement work, which takes rank among the most effective means of increasing the efficiency of American dairying.

Studies of Dairy Sanitation

Valuable results have come from studies of dairy sanitation by the bureau. How to handle milking machines so as to produce milk of low bacterial count is a problem on dairy farms. The bureau has evolved a simple, inexpensive method of cleaning and sterilizing such machines. This method, which can be used on any farm, enables the dairyman under average farm conditions to produce milk even in the summer with an average bacterial count as low as 2,000 or 3,000 per cubic centimeter.

Another recent contribution to dairy sanitation made by the bureau is the demonstration of economical methods for producing steam

on the small dairy farm for the sterilization of utensils. City health departments often require steam sterilization of all dairy utensils, because the unsterilized utensil is the greatest source of bacterial contamination in fresh milk. Tests made by the bureau cover sterilizing cabinets constructed of wood, concrete, and galvanized iron. Other tests were made with a small galvanized water heater and steamer. The first device mentioned requires a steam boiler for its operation and the second does not. When the tests were completed blue prints of approved types of sterilizers were drawn up and sent to dairymen, milk inspectors, and other interested persons. The tests showed the bacteriological efficiency of the different appliances examined and also the cost of operation of each type.

Milk dealers, as well as milk producers, are confronted with bacteriological problems. One such problem is how to obtain milk of a low bacterial count, and another is how to handle milk so that it will not become recontaminated. In order to learn where and how recontamination of milk chiefly occurs, studies were made at 97 milk plants of varying size and type. These studies showed that the management and proper cleaning of equipment in the milk plant are of vital importance, and indicated also that the importance of proper distribution of refrigeration in cold-storage rooms is not always recognized. Variations in temperature amounting to as much as 15° F. sometimes exist in different parts of a cold-storage room. This knowledge has led to further studies in methods of air circulation and in the arrangement of refrigerator rooms.

It is well known, of course, that the conservation of milk in a condensed, evaporated, or desiccated form is based on the destruction of bacteria or on the creation of conditions tending to prevent the development of bacteria. It is also a matter of common knowledge that the flavor of butter and cheese depends greatly on the encouragement of bacteria producing desirable effects and on the suppression of bacteria tending to cause spoilage.

Bacteria Growth Rate

Accordingly the bureau has studied conditions governing the rate of growth of bacteria, the effects of growth of one species on another species, and various other bacterial problems. It has been discovered that the cells in passing through different stages of normal growth undergo physiological changes which exercise a marked effect on the resistance of the bacteria to heat and other unfavorable conditions. Bacteria in the rapidly growing stage, for example, can be more easily destroyed than is possible after they reach a more dormant condition. This knowledge has a practical application in the preparation of "starters." It has also been successfully applied in the development of methods to suppress abnormal fermentations in cheese.

Some of the bureau's recent contributions to our knowledge about dairying, while of the highest practical value, involve more technical description than can be given in this report. The examples cited are intended merely to give an idea of the character and value of the work done. An easily grasped instance is the application of an investigation recently made on the viscosity of milk and cream. Viscosity is important commercially because it affects the whipping

quality of cream and the appearance of table cream. Cream with a poor viscosity, even though containing the requisite amount of butterfat, appears thin to the consumer. A dealer selling such cream is consequently at a disadvantage when competing with another selling cream having the same butterfat content but greater viscosity. The department's researches into this problem led to the development of several methods for increasing the viscosity of cream. Methods have also been developed whereby the destruction of viscosity by different practices in milk-handling plants may be prevented. In the same connection valuable data have been obtained regarding the effects on milk and cream of temperature, aging, acidity, heating, and other factors. Methods have also been developed by which strongly flavored feeds may be given to dairy animals without tainting their milk. This is of great importance, because losses from off-flavored milk amount to many million dollars annually.

Better Cheese Making Facilitated

More efficient methods of cheese making have been developed as the result of investigations conducted in the dairy bureau. These investigations have sought, first, means of encouraging the domestic production of kinds of cheese now largely imported; and, second, means of controlling the abnormal fermentations that cause losses by lowering the quality of cheese. It is estimated that gassy fermentations decrease, by from 3 to 10 cents a pound, the value of a considerable proportion of our domestic production of Swiss cheese. In both these directions progress has been made. Better methods have been demonstrated for making Swiss cheese equal in appearance and flavor to the best imported product, and pure cultures have been introduced for the control of abnormal fermentations. These have come into general and successful use, with the result that the average quality of domestic Swiss cheese has been decidedly improved. Two characteristic defects—pressler and niszler—appear in the abnormal gassy fermentations of cheese. Studies have shown that these defects are caused by the same organism and that the time and character of the fermentation are determined by the physiological condition of the cells when the cheese is made. This knowledge has made it possible to obtain a maximum development of the corrective cultures at the stage when they are most effective in suppressing undesirable gas formers. Great success has attended the application of these methods in our domestic cheese factories and they are now widely applied.

One of the most serious difficulties met with in the evaporation of milk is coagulation during the sterilizing process. Accordingly, investigations have been conducted to determine the conditions under which milk is stable or unstable under the action of heat. Within certain limits there is no reaction under which milk will invariably be stable. The optimum reaction varies with the milk of individual cows, and a very small change from the reaction giving certain milk its maximum stability will produce a great change in the temperature of coagulation. From this discovery to its practical application is only a step. The amount of heat treatment which the milk receives before its concentration is an important factor in controlling the coagulation temperature. A relatively low temperature at that stage

gives a low stability but a heavy body. As the temperature approaches the boiling point, the product gains in stability while losing in body. In making sweetened condensed milk these conditions are reversed. In that process a low "forewarming" temperature tends to prevent the thickening that usually develops in the product sooner or later. It has also been demonstrated by the bureau that the heat treatment of milk is an important factor in making dried skim milk, which finds a profitable outlet in bread making. When the dried product is made from preheated milk, its use in bread gives remarkable values. The loaf is improved in nutritive value, in color, in texture, and in flavor. Moreover, a larger loaf is obtained, so that under favorable conditions the increased output offsets the cost of the dried milk.

Ice-Cream Making Studies

Studies of ice-cream making have given important results, particularly in explaining and preventing the phenomenon known as sandiness. Valuable knowledge has also been gained regarding the preference of the consumer for certain combinations of ingredients. Methods of incorporating fruit in ice cream affect markedly the consumer's choice. The bureau is promoting the use of dry skim milk in ice cream and other food products, and the manufacture of dry skim milk is already an important industry. Other studies now under way are directed to solving the problem of converting the proteins of skim milk, buttermilk, and whey into acceptable forms of human food. There is a decided shrinkage of food value when these products are converted into pork, veal, or poultry. Great financial loss results from total failure to turn milk by-products into marketable commodities.

The department's by-product studies have developed a process of converting dry skim milk into a nonperishable poultry food, by a technic well adapted to factories handling only a relatively small supply or those not in a position to buy equipment for making dry skim milk. By this means large quantities of skim milk are now conserved. More difficult is the problem of utilizing whey. Only a limited use exists for lactose, the chief ingredient of whey, and no product has yet been made from lactose which can not be made from a cheaper sugar. Further investigations on this problem, however, will doubtless bring results of practical importance.

PROGRESS OF ECONOMIC ENTOMOLOGY

The conditions which man finds best for his progress and prosperity are unfortunately exactly those which are most favorable to insects. The cultivation of enormous areas of cotton in the South, of corn and wheat in the Middle West, and of citrus groves in Florida and California, permits the insects that feed on these crops to multiply in destructive numbers. Losses from insect pests in the United States amount to probably not less than \$2,000,000,000 annually. But applied entomology keeps the losses down. Were it not for control methods developed by entomologists, the yearly toll would probably be as large again. New methods of control are constantly being found and old ones improved. Growth of economic entomology has

been very great in recent years, largely as a result of increased understanding on the part of the public of the necessity for insect control in successful agriculture and in human affairs generally.

During the last two or three decades the number of scientists engaged in entomological work in the Federal Bureau of Entomology and at the agricultural colleges and experiment stations, and the funds devoted to this work, have materially increased. In the Federal Bureau of Entomology the number of entomologists employed this year was 320, compared with 80 in 1905, and funds appropriated for research and control operations this year were thirty-six times the sum appropriated in 1905. Insect problems have been pressing in the period mentioned, and this fact has naturally contributed to increased appreciation of the work of the entomologist. The establishment in the United States of such pests as the San José scale, the cotton-boll weevil, the gipsy moth, the Japanese beetle, and the European corn borer has necessitated vastly increased activity in the war against our insect enemies.

Much of the work of the Federal bureau is in cooperation with State workers, especially on projects of interstate interest. Most of the bureau's operations, however, are conducted at some 80 field stations located where different pests are troublesome. Some work, particularly the importation of beneficial insects to prey on different introduced insect pests, is carried out in foreign countries in cooperation with foreign governments. Entomologists are convinced that the control of insects by the utilization of their natural enemies offers great possibilities. Accordingly, steps are being taken to effect an exchange among various countries of the beneficial insects that live at the expense of other insects.

Japanese-Beetle Control

Improvements continue to be made in methods and materials used for the control of the Japanese beetle. A miscible carbon disulphide has been perfected for use in the control of larvæ in the soil. It is much superior to the various types of carbon disulphide emulsion previously used, since it can be applied effectively even when the soil temperature is as low as 35° F. Serious difficulties arose in the commercial production of oleate, or coated lead arsenate. Successful investigations leading to certain changes in methods of its manufacture have made available a standardized and improved product. This material more than any other is used in the control of the Japanese beetle.

Traps baited with the attractant geraniol are coming into more general use. Under certain conditions these play an extremely useful part in facilitating the capture of large numbers of the beetles. Their use thus far has been restricted, however, and does not take the place of timely and thorough spraying. The pyrethrum-soap spray, developed for use against the Japanese beetle, has proved a useful contact insecticide against other insects as well. It has been found effective against the striped cucumber beetle, the squash bug, and other insects heretofore difficult to kill. By incorporating a small percentage of sodium silicate in this soap its toxicity has been greatly increased.

The value of community effort in the control of the Japanese beetle has been officially recognized by the States of New Jersey and Pennsylvania. During the past year 12 communities in New Jersey and 3 in Pennsylvania conducted community spraying campaigns, and twice as many communities are planning similar campaigns for next year. Five species of oriental parasites of the Japanese beetle are now established in New Jersey and Pennsylvania. In one locality near Riverton, N. J., 25 per cent of the beetles were found parasitized during the year 1927.

Recognizing the impossibility of the eradication of the European corn borer and its inevitable spread into the middle Corn Belt, the department in cooperation with the States concerned has developed a definite and comprehensive program to retard the spread of the borer, and prevent as far as possible its increase. The department proposes to finance scouting to determine the further spread of the borer as a basis for quarantine measures. Quarantine enforcement within States will of course be done under delegated State authority. Responsibility for scouting and quarantine enforcement is accepted by the department to release State funds and personnel hitherto used in such work. In this way State departments of agriculture will be enabled to give their undivided attention and resources to the problem of holding the increase in the number of borers below serious commercial damage. The department's program also provides for research work in all fields related to the borer problem. It welcomes the fullest cooperation on the part of the States in coordinated research activity and practical control measures. The department and the State agricultural colleges will continue an intensive educational campaign now being conducted by their cooperating extension service in the infested territory.

Insect Infestation of Flour

It became increasingly evident several years ago that if American flour is to be exported to Europe and elsewhere in competition with other flours some way must be found to reduce insect infestations. Serious losses had been suffered by exporters; it seemed probable that unless improved conditions could be brought about our export trade in flour would be jeopardized. The export market absorbs a large quantity of flour, and any contraction of the outlet would have a serious effect on the entire milling industry. In locally consumed flour, insects can be easily dealt with provided interested parties will apply available control methods. Export flour, however, must run the gantlet of the home milling plant, railroad freight cars, storage at docks and ship terminals, and finally ship transportation. Hence the problem of protecting it from destructive insects is complicated by factors beyond the control of the exporter.

The immediate crisis in insect infestation in export flour has been met and the danger greatly reduced by the cooperation of flour-mill owners, railroads, ship terminals, and steamship lines. Mills exporting flour are systematically fumigated or heated for the destruction of insects at the point of origin of the flour. Railroad freight cars are fumigated to lessen the likelihood that flour will become infested en route between factory and ship terminals. Inspections

are made of flour on arrival at the exporting point. Dock terminals are kept as sanitary as possible. Ships carrying export flour are inspected before each shipment is loaded, and fumigated by approved methods if insects are found present. Combined official and unofficial effort has accomplished notable results.

In order to prevent the spread of the gipsy moth farther west than the area of infestation in the New England States, a barrier zone was established in 1923 extending from the Canadian border on the north to Long Island Sound on the south, a distance of some 250 miles. The zone, which is 30 miles wide, is flanked on the west by the Hudson River and farther north by a tier of towns in New York State west of Lake Champlain. It is located along the shortest possible line that could be drawn to cut off the area infested with the gipsy moth from the rest of the United States. This strip of territory avoids the rugged Catskill and Adirondack Mountain regions in New York State and the Green Mountain range in Vermont, but considerable difficult country is included in the Berkshire Hills region in Massachusetts and northwestern Connecticut.

Strenuous efforts are being made to clean up existing colonies and keep the zone free from the gipsy moth. The number of colonies of this insect has been reduced and some of the towns on the western side have been released from continuous inspection. At one time three small colonies of the insect were found west of the Hudson River, but two of these have already been exterminated. Thus far the work in the zone has made satisfactory progress and the westward spread of the pest has been checked. However, at the present time these substantial results are threatened by the rapidly increasing abundance of the pest in the region adjoining it to the east and special efforts will be necessary to maintain the benefit which has already been secured.

Insect Carries Curly-Top Disease

From the fact that the sugar-beet leaf hopper, a small insignificant insect, is the carrier of the so-called curly top of the sugar beet, it is proving to be the limiting factor in the extension of the sugar-beet industry in the intermountain region. Where factories are situated close to the natural breeding grounds of the insect, as in the Twin Falls-Burley district in Idaho, the disastrous season of 1926 brought the industry in those places to the lowest ebb in its history. Fortunately, studies of the insect in its desert breeding grounds and the relation of the insect to weather conditions had progressed to the point where the information could be made available to farmers. Available data indicated prospects for a favorable beet year in 1927 in the Twin Falls-Burley district. A prediction to that effect by the Bureau of Entomology encouraged growers and led to the planting of a large acreage, which proved the most profitable on record.

This year applied entomology rendered beet growers an equally unmistakable, though different, service. The situation prior to planting indicated that beet growing would be attended by serious hazards. With the hearty cooperation of the sugar-beet industry, a prediction was issued to that effect. It is conservatively estimated that in one factory district alone 10,000 acres of beets would have been planted

had it not been for this prediction. The desirability of avoiding plantings in years of serious outbreak, and conversely, of heavy plantings of sugar beets in years when prospects are good has thus been demonstrated, and the prediction service is rapidly becoming established as an essential part of the agricultural program in a large and highly developed irrigated area.

Cattle Grubs Cause Heavy Loss

Livestock raisers in the United States suffer heavy loss from the effects of two closely related grubs that attack cattle. Though distributed among many different livestock enterprises, this loss falls heaviest on dairymen and cattle feeders. It is of such a nature, moreover, as not to be entirely apparent to stock owners, and the seriousness of the situation is not fully appreciated. In an effort to cut down the damage inflicted by cattle grubs, the department has embarked on an extensive research program and has initiated control undertakings in various parts of the country. It is hoped that in time the pests can be eradicated. Losses resulting from the infestation of cattle by grubs include reduced milk flow, impaired flesh condition, and sometimes the death or injury of animals. Serious damage is also done to hides, with the result that manufacturers have established a rather definite system of dockage for all grubby hides and leather produced therefrom. Carcasses of animals slaughtered during the season of grub infestation must be trimmed. This results in loss of time, wastage of 1 or 2 pounds of meat per animal, and a lower sale value due to the unsightliness of the trimmed meat. Some estimates of the damage caused annually by cattle grubs run as high as \$100,000,000.

WILD-LIFE ADMINISTRATION

The need for taking measures to improve the wild-life situation continues. The increasing utilization of lands for agricultural and industrial operations and for the extension of urban conditions is not favorable to the continuance of some forms of wild life. It even threatens local extermination of many game and other species that are dependent upon marsh and water areas. Remedial measures are being taken by the department in a conservation program. The Bureau of Biological Survey is continuing wild-life research, the administration of wild-life refuges, cooperative work to curb the destructiveness of injurious species, and the administration of protective laws, with a view to the adoption of a broad policy in the conservation, utilization, and control of the wild-life resources of the country.

A forward step in wild-life conservation during the year was the congressional enactment of a measure to establish the Bear River Migratory Bird Refuge at the mouth of Bear River, Utah, authorizing an appropriation of \$350,000, of which \$200,000 was made available to begin the work and carry it through the fiscal year 1929. This will permit diking and ditching in the Bear River marshes and the impounding of fresh waters covering approximately 45,000 acres, thereby creating a good feeding, resting, and breeding ground for wild fowl. Besides providing a great bird refuge, the work will help

to prevent loss of birds through alkali poisoning. Difficulty experienced in securing land for the extensive upper Mississippi River Wild Life and Fish Refuge has been lessened by another Federal enactment authorizing the department to increase from \$5 to \$10 an acre the average price that may be paid for the land needed. This will result in the acquisition during the coming year of a large additional area. Wild life has increased on that part of the refuge now under the control of the department.

Accurate knowledge concerning the food habits of various species is necessary in appraising the economic value of American bird life. For more than 40 years the Department of Agriculture has played a leading part in this important field of research. Its work is invaluable in helping to solve problems arising from the varied relations of bird life to agriculture, horticulture, and forestry. Excellent codes of laws, both Federal and State, affording legal protection to beneficial species throughout the country, have been enacted largely as a result of knowledge gained in field and laboratory research. Methods of attracting beneficial insectivorous species about farm and home grounds have been evolved from the study of the food habits of such birds, and areas suitable for wild fowl have been improved. Facts helpful in the development of control measures for the comparatively few species requiring control have been disclosed. During the past fiscal year the food of some 1,555 birds was studied, bringing to nearly 99,000 the total number of bird stomachs examined by the Bureau of Biological Survey since this work was first undertaken.

Censuses Taken of Waterfowl

In order to obtain more comprehensive and reliable information regarding the abundance, distribution, and movements of waterfowl as a basis for adequate regulations under the migratory bird treaty act, a series of censuses was begun during the year in cooperation with the Office of National Parks of Canada. At more than 3,000 stations in important breeding, migration, and concentration areas of the birds, observations and reports are made by volunteer co-operators each month. State and provincial departments of game and conservation and National, State, and provincial organizations, of sportsmen and conservationists, as well as several bureaus of other Federal departments, have participated in organizing the work. Reports received totaling many thousands give far more detailed and complete information than has heretofore been available. Information from the first year's reports has been mapped to show in a graphic way conditions that must be considered in programs to insure the maintenance of waterfowl in satisfactory numbers.

Good progress has also been made in research work on the seasonal movements of birds. Reliable information is obtained through field observations and the application of the bird-banding methods of investigation by representatives of the department and cooperating organizations and individuals. More than 1,400 banding stations are established throughout the country, reports from which showed approximately 127,000 birds banded during the year, with return records totaling about 7,000 from more than 400,000 banded since 1920.

Cooperation of State game authorities and others with the Federal game protectors has brought about a better observance of the migratory bird treaty act, with a corresponding improvement in conditions affecting migratory birds. The problem of providing further protection to the woodcock has given the department considerable concern. Many persons, believing these valuable game birds are decreasing throughout the range, have urged a closed season of from three to five years. Others, particularly in the New England States, say the birds are increasing, and protest against further restrictions on hunting. After consultation with the migratory bird treaty act advisory board, State game authorities, and others, the open season on woodcock throughout its entire range was shortened to one month.

Conservation of Elk, Buffalo, Etc.

The solution of serious problems concerned with the care of large numbers of buffalo, elk, deer, and antelope on reservations maintained by the department is complicated by lack of funds for proper administration. On some ranges interior fencing is needed to protect the grass by rotation grazing. It has been and will continue to be necessary to dispose of the annual surplus of buffalo and elk on some preserves in order to insure sufficient forage for herds of even the present size. If any of the herds are to be permitted to increase in size, additional grazing space must be provided.

The problems on the elk refuge maintained by the department near Jackson, Wyo., detailed in my report last year, are still serious. Following recommendations made by a commission appointed by the President's Committee on Outdoor Recreation, a biologist familiar with big-game animals has been engaged in studying the Jackson Hole elk herd and all conditions affecting their welfare, including their breeding and feeding habits, seasonal movements, range and food requirements in relation to livestock, and the diseases, parasites, and other factors involved in depleting their numbers. The program calls for one of the most complete and systematic studies ever undertaken of any species of big-game animal in the United States. Results already obtained indicate that necrotic stomatitis induced by eating hay containing wild barley is one of the most serious causes of loss on the winter feeding ground.

A maximum of 9,000 elk were fed at the elk refuge during the past winter, and when feeding ended very little hay was left on hand. If the coming winter is mild the available supply of hay will probably suffice, but if the season is severe the crop raised at the refuge, even though supplemented by hay purchased by the State of Wyoming, will be insufficient and there will be great mortality among the elk. The refuge area should be further enlarged by the inclusion of suitable adjacent hay and grazing lands so as to provide a crop of hay ample to meet requirements under all conditions.

At the request of the board of game commissioners of Pennsylvania, a field naturalist of the Bureau of Biological Survey was detailed to investigate conditions attending heavy losses of deer in certain sections of that State. His studies revealed overstocking and overgrazing and the consequent starvation of thousands of young deer. The analysis thus made affords a sound basis for adoption of

corrective measures in Pennsylvania, and is proving exceedingly helpful to Federal and State officials in appraising conditions detrimental to deer in other regions.

Forest Life Studied

Investigations of the activities and habits of wild mammals and birds that inhabit forested areas have been undertaken and efforts made to determine their relation to forest production. In these studies forest wild life has been viewed not only as a source of food, fur, or other products, but also as an agency in the control of insects, rodents, or other species destructive to forests. The investigations cover the beneficial activities of forest animals, such as their distribution of seeds, their injurious habits, such as the eating of seeds or seedlings, the killing or deforming of trees, and their competing with livestock in the consumption of forage. Information of much value has been obtained bearing on the desirability of conserving and increasing the number of beneficial or valuable species and on the need for control measures where undue damage is done. Work on this project will be continued.

Fox farming in the Northern States and the raising of fur bearers in captivity throughout the country have increased the calls upon the department for aid in solving numerous problems. The fur-animal experiment station at Saratoga Springs, N. Y., and the rabbit experiment station at Fontana, Calif., both maintained by the department, are operated for the purpose of studying the habits of fur animals in captivity, and problems in feeding, housing, sanitation, and parasite control. To supplement work at the experiment stations, diseases of fur animals are studied in cooperation with the University of Minnesota with a view to controlling losses which on many fur farms are extensive. Investigations also are made in cooperation with the Alaska Game Commission for the improvement of conditions on fur farms in the Territory.

The pelts of fur animals raised in captivity are coming to be more in demand on the market from the fact that, taken at the season when they have reached their maximum quality, they are usually of uniform texture. The demand for attractive and durable furs for wearing apparel has greatly stimulated the fur-farming industry. Incidentally, species of valuable forms of wild life are preserved, though the industry can not take the place of natural conditions in perpetuating fur-bearing animals.

Losses from Predatory Animals

The depredations of such predatory wild animals as coyotes, wolves, mountain lions, bobcats, and lynxes have caused millions of dollars loss in livestock in the range States. Likewise, such injurious small mammals as prairie dogs, ground squirrels, jack rabbits, field mice, pocket gophers, rats, woodchucks, and porcupines have destroyed millions of dollars' worth of agricultural crops. The policy of the department in control operations against injurious mammals and birds, as definitely stated recently, is to reduce losses through the local eradication of stock and crop pests where agricultural and

other economic activities demand such action. It does not contemplate the general extermination of harmful species, even if that were possible. This policy is being made known by field leaders of the Bureau of Biological Survey to their cooperators in order to clear up misapprehensions that have been entertained by many who are working for the conservation of wild life.

In control campaigns directed by the department against predatory animals during the year the skins or scalps of 35,709 coyotes, 9 large-gray wolves, 716 red wolves, 219 mountain lions, 40 lynxes, 4,838 bobcats, and 226 predatory bears were taken in 13 Western States, thereby effecting an estimated saving of more than \$5,000,000 in livestock. This was done in cooperation with State and county agencies, livestock associations, and individuals. Congress has authorized an investigation by the department of the feasibility of a cooperative program to extend over five or more years for the eradication, suppression, or bringing under control of predatory animals, and of the estimated cost as compared with present methods. A report will be made to the next regular session of Congress, based in part on field operations and on research work that has been in progress for several years at the department laboratory at Denver, Colo.

Organized rodent-control operations were carried on by the department during the year in cooperation with agricultural colleges, county agents, State departments of agriculture, county officials, farmers' and stockmen's associations, and other Federal departments in 18 States, and educational work on the subject was undertaken in 10 others. In the field campaigns 1,653 tons of poisoned bait, and approximately 71 tons of calcium cyanide, and 313 tons of carbon disulphide were used to destroy rodent pests on 14,545,591 acres of Federal, State, and private lands. This resulted in savings in crops conservatively estimated at \$5,800,000.

Protecting Reindeer Against Pests

Investigations conducted at the reindeer experiment station of the Bureau of Biological Survey, at Fairbanks, Alaska, and on typical grazing areas throughout the Territory continue to yield valuable information regarding the nutritive qualities of lichens and supplementary foods, the carrying capacity of lichen range, and the recovery period following grazing. Information also is being obtained there regarding the warble and nose flies, which are among the most serious pests of reindeer and caribou in Alaska. Studies of the life history of these flies, including the collection and rearing of grubs, indicate that a large measure of protection can be had by concentrating the herds at fawning time, when also the grubs are dropped, and then moving them to an area about 20 miles distant.

Assistance also was given reindeer owners in Alaska at the round-ups in demonstrating improved methods of counting, marking, and ownership distribution of animals, and information was given regarding improved methods of breeding and feeding. Studies were made at Washington, D. C., in cooperation with the Bureau of Education of the Department of the Interior regarding the most satisfactory market cuts of reindeer carcasses, the chemical and nutritive properties of the meat, and methods of dressing, handling, storing, and

cooking. Experiments in cross-breeding reindeer and caribou have been successful in producing young weighing approximately 5 pounds more than reindeer fawns at birth. Plans for fencing pastures and corrals contemplate handling about 75 reindeer and caribou for use in the experimental investigations.

FEDERAL EXPENDITURE FOR RESEARCH

This report, although citing only a few of the results achieved by the department through scientific research, presents so formidable an array of accomplishments that research activities may seem to be adequately manned and financed. That is not the case. Federal expenditure for research in agriculture is not large considering the magnitude of the problems awaiting solution. Much less money is expended in the United States for agricultural than for industrial research. The department's research program should be expanded. I need not emphasize the fact that expenditure for wisely directed scientific research is a sound investment. Every dollar expended by this country heretofore in agricultural research has been returned many thousandfold in savings to farmers and to the Nation. Examples already cited in this report give some inkling of the dividends paid on funds invested in scientific investigations.

Yet many problems of the greatest importance lie practically untouched, and the department's research units are inadequately financed. Funds already provided are fully absorbed by the necessity of dealing with problems of pressing importance. It has been necessary to postpone work of a broad and fundamental character in order to tackle immediate problems. This is probably not the most economical procedure, for some of the greatest achievements in agricultural science have resulted from investigations undertaken primarily to reveal scientific truths, rather than to win immediate economic returns. Until a few years ago the funds available for research in the department were not increased sufficiently to offset the declining purchasing power of the research dollar. As a result agriculture lagged, while business and industry made great forward strides in the application of research to their practical concerns. Although funds were provided to meet other needs such as the eradication and control of insect pests and the enforcement and control of regulatory laws, research funds remained about stationary or showed only a slight increase here and there to meet specific requirements.

Expenditure by the department for research during each of the fiscal years 1921, 1922, and 1923 was about \$9,000,000. This is a rough estimate, because expenditures made by the department in those years were not classified in detail. In 1924 classification of expenditures showed a total of \$9,700,000 devoted to research. This sum was increased in 1925 to \$10,100,000, in 1926 to \$10,300,000, and in 1927 to \$10,600,000. In the fiscal year 1928 the total was \$11,300,000. In the same years expenditures for other activities also were increased. In consequence the proportion expended for research, although fluctuating somewhat from year to year, remained about 6 per cent of the department's total expenditures, and about 23 per cent of what may be called the department's expenditures for ordinary activities. In the total expenditures there are included outlays for roads and various other forms of Federal aid to the States.

Work Is Inadequately Financed

This relationship between expenditure for research and for other department activities shows, I think, that research is inadequately financed. I believe we can safely expect increased expenditure for research to bring returns equal to those accruing from similar expenditure heretofore. In view of the needs of the agricultural industry, which represents a capitalization of nearly \$60,000,000,000, the present Federal allocation of funds for agricultural research is modest, to say the least. As a matter of fact, the Federal Government and the States together expend scarcely \$20,000,000 annually for research activities, compared with probably \$180,000,000 expended annually by private industries for a similar purpose. Additional funds might be advantageously provided regularly to increase research activities and to maintain existing studies on a sound footing.

Funds for research must, of course, be provided largely through taxation, and the expenditure of such funds should therefore be managed with care and economy. This principle is sedulously kept in mind by the department. A business policy has been put into effect which takes into account the necessity of making no expenditure except on a definite prospect of a full return. This principle, however, does not exclude, but rather encourages, the support of research work. It would be false economy to restrict our national investment in agricultural science. Scientists should have adequate funds to do their work and adequate pay. Money provided to satisfy these requirements may generally, if care is taken to see that it is used for its proper objects, be set down on the credit side of the ledger.

The figures I have given show that up to the fiscal year 1928 only moderate increases were provided in the department's research appropriations. In the appropriation bill for the fiscal year 1929, however, Congress granted a material advance. Increases were provided for research projects involving an additional expenditure of \$1,800,000. This substantial encouragement, the longest forward stride in a number of years, may, I hope, be considered the beginning of a program which will result in materially increased assistance to scientific work. The increased appropriations provided for the current fiscal year will help greatly in dealing with various urgent problems.

Endowment of Experiment Stations

In addition to the increased appropriations made available directly for the department's work, Congress has enlarged the Federal endowment of the State agricultural experiment stations. This has been done under the Purnell Act, approved February 24, 1925, under which measure the State agricultural experiment stations are enabled to inaugurate many new lines of research as well as to strengthen research projects already going forward. Special provision is made for research in marketing and in other phases of agricultural economics, and also in home economics. Great stimulus to agricultural research has resulted already from the passage of the Purnell Act, and the ultimate good which will be derived therefrom can not be estimated.

Prior to the passage of the Purnell Act each State received \$30,000 annually for research from the Federal Government under the Hatch and Adams Acts. The Purnell Act authorized increases to each State in annual increments of \$10,000 each for the fiscal years 1926 to 1930, and \$60,000 annually thereafter. Thus the Federal grant to each State for agricultural research will be brought, in 1930, up to \$90,000 annually. Funds thus authorized are provided annually in the appropriation act of the Department of Agriculture and are paid to the States upon approval of proposed research projects. In this way the cooperation of research agencies for the efficient coordination of research is promoted. Congress this year extended the provisions of the Purnell Act to the Territory of Hawaii, beginning with the fiscal year 1930.

All told, therefore, the increased research funds provided by Congress for the fiscal year 1929 amount to \$2,280,000—\$1,800,000 for the department's research program and \$480,000 for payments to the States under the Purnell Act. This is very satisfactory progress. Further evidence of the interest taken by Congress in agricultural research was furnished by the enactment, at the last session, of the McNary-McSweeney Forestry Research Act, authorizing appropriations for research in all phases of forestry, including the production of timber, the utilization of forest products, and forest economics. Appropriations authorized by the act involve fixed annual amounts for various phases of forestry research over a 10-year period. A new chapter in the history of our forest management and conservation is thus started.

FORESTRY AND AGRICULTURE

The importance of wood as a farm product is seldom realized. Data on the forest products derived from farms of the United States are gathered only once in 10 years by the census. In 1919 the reported value of such products totaled nearly \$395,000,000, as against slightly more than \$195,000,000 in 1909 and less than \$110,000,000 in 1899. What change from the 1919 figures those for 1929 may show is, of course, wholly uncertain, especially since 1919 was a year of abnormally high prices. Nevertheless, in the long run undoubtedly wood will constitute an increasingly valuable farm crop.

It makes possible the productive use of much farm land that otherwise could earn nothing and adds to the value of considerably more. It is a crop which does not have to be harvested and disposed of irrespective of market conditions each season, but on the contrary can be left in place to accumulate like money in a savings bank. It is both a cash crop and a means of supplying economically farm requirements that would otherwise necessitate cash outlays; 55.2 per cent of the reported 1919 farm-forest products value represented products sold or cut and held for sale and 44.8 per cent products for use on the farm as building material, fence posts, poles, etc., and as fuel—the latter the chief item. In total value the farm-forest products of 1919 came to more than three times that of sugar beets and sugar cane combined, nine-tenths that of all orchard fruits, approximately three times that of all citrus fruits, not very far behind that of tobacco, and more than four-fifths that of spring wheat.

Relatively little of this value was obtained through forest culture. The 1920 census reported approximately 168,000,000 acres as the area of woodland included in farms. Only 21 per cent of this was classed as timberland; that is, with trees mostly of saw-log size. In part this timberland is land still under virgin forest. Other portions are under second growth, that has succeeded the original stand not as a result of any practice of forestry but as a gift of nature. In small part only do the saw-log stands represent a deliberate purpose to grow timber. In some part they doubtless occupy land which the owner expects to clear. Likewise the 79 per cent of our farm woodlands that does not have trees mostly of saw-log size is largely in a wild-land condition.

More and Better Farm Forestry Needed

Of the total farm area of more than 950,000,000 acres at the time of the last decennial census more than 1 acre out of every 6 was farm woodlands, and in the naturally forested regions the proportion is of course much greater. While a certain amount of this land will in time be brought under tillage, other land not now occupied by tree growth will be reforested, naturally or artificially. In my report of two years ago I pointed out how in some parts of the East the amount of improved farm land began to lessen well before the end of the last century, declining between 1880 and 1920 in the North and Middle Atlantic States by some 13,700,000 acres. The reversion of once-cleared pasture and of lands formerly cultivated to forest growth is a part of the process of adjustment of land use to economic conditions—an adjustment which, as I took occasion to say in the earlier report, should be hastened rather than delayed, in the interest of greater agricultural stability. Farm forestry affords a means in the timber-producing regions of putting to its best use much of the poorer land which if cultivated swells the crop surpluses without giving the farmer a fair return. The present acreage of farm woodlands is approximately twice that of the productive timberland in all the national forests, and acre for acre can on the average grow more wood. From every standpoint there are strong reasons for developing and making known to our farmers the methods whereby this great aggregate of potentially timber-producing land may be used most effectively and most profitably to them.

This will be a very large task. Most farm woodlands are in bad condition. Generally speaking, the make-up of the forest growth has been so altered through fires, through overgrazing, and through cutting without regard for, or knowledge of, the consequences—through prolonged treatment as wild lands, in other words, and through lack of proper protection and care—that many years of well-directed, skillful handling will be necessary to rejuvenate them and convert them into thrifty, well-stocked stands of the best kinds of trees. They are much like ill-tended gardens full mostly of weeds. But though largely run down, they can be built up and restored through use. Forestry is applied chiefly in the process of cutting—by taking out what is not wanted in the future forest and giving what is left the best conditions for growth and reproduction. There is no reason why the farm woodlands should not keep on providing fuel,

fence posts, construction and repair material, and salable products essentially as they are now doing and yet improve steadily in value and growing power.

Markets for Wood-Lot Products

Along with the process of working over the wild-land farm wood lots into well-conditioned little forests will have to go the process of developing suitable markets for their products. There are cases in which the market is developing first and leading the way for the farmer. A New England box manufacturer, for example, employs a forester whose advice can be obtained free of charge by farmers in the territory from which the factory draws its raw material; and a North Carolina paper mill is endeavoring to build up a source of sustained supply of the pulp wood which it consumes by interesting farmers in its neighborhood in continuously growing suitable wood, and in cutting yearly the equivalent of the annual increment.

There is, however, for most wood-lot owners as yet no ready means for selling to advantage a small yearly output of material for industrial use; and this is doubtless one reason why the wood lots do not produce relatively more of such material as against firewood and other products of scrub forests.

Public Encouragement Necessary

The only way that the latent possibilities of timber growing as a means of utilizing the portions of farms better suited to wood crops than field crops or pasturage can be developed within a reasonable time is through public encouragement. For this there is ample ground. There is greater danger of a shortage of timber supplies within the next 50 years than there is of a shortage of food supplies; and both from the standpoint of the promotion of general prosperity and from that of the promotion of rural welfare, intelligent, skillful use of the enormous total acreage which should be utilized for timber growing is of prime importance.

For such public encouragement the way is already blazed. The Clarke-McNary law, passed in 1924, authorized and directed the Secretary of Agriculture to cooperate with the various States in producing and distributing material for planting portions of farms needing artificial forestation or reforestation. It also authorized and directed cooperation with State officials or other suitable agencies in assisting farmers to establish, improve, grow, and renew useful timber crops, windbreaks, and shelter belts. And the McSweeney-McNary law, enacted last spring, authorized the inauguration of a far-reaching program of Federal research in forestry which for the first time affords the prospect that the basic knowledge essential for skillful timber growing will be progressively obtained at a rate commensurate with its importance.

The cooperative work designed to assist farmers to grow timber crops is organized as a part of the agricultural extension work of the department. It is indeed fortunate that this great educational agency for disseminating knowledge of desirable practices as they are worked out and for promoting their adoption is available to hasten

progress. The educational task to be performed, however, is greater than any single agency can be expected to carry out entirely. It must enlist all the agencies that can be utilized to incorporate forestry in the practice and transmitted lore of agriculture. It must give us forest-minded farmers, must develop for their observation and instruction multitudinous practical examples of applied silviculture, and must permeate our agricultural colleges and high schools, our agricultural press and literature, and our agricultural leadership, national and local, with sound conceptions.

A Field for Cooperative Effort

It is the duty of the Department of Agriculture to do all that it can not only through the Extension Service but through every means at its command to build up farm forestry. The field is preeminently one for cooperative effort, since there are involved both a national interest in permanent supplies of forest products and in efficient land use and to no less degree State and local interests in the same matters. As rapidly as is feasible the cooperative activities under the Clarke-McNary law for the promotion of farm forestry should be enlarged. Most of the States now have at least started State forestry work, and some have seasoned strong organizations. The State forestry departments should play an important part in the educational movement for familiarizing the public generally with good timber-growing practices.

In spite of all the public attention that forestry has received and all the public interest that forest preservation has aroused, the true nature of the problem to be worked out is seldom fully grasped. It is thought of in too narrow terms. There is much anxiety—and with reason—over the question of adequate future timber. There is widespread recognition of the necessity to prevent forest fires. There is a general desire to keep the country well supplied with forest growth as a protection to stream flow and for other indirect benefits, including scenic protection and recreational enjoyment. There is what can perhaps best be described as a sort of instinctive dislike and disapproval of deforestation that is not promptly followed by agricultural development, as a public loss and injury. All these things are embraced in the forest problem, but they are merely single aspects of it and do not go to its heart.

Forest Administration Misunderstood

Similarly, the true nature of the undertaking involved in public forest administration frequently fails to be recognized. It is in danger of being thought of as essentially the business of disposing of forest products, dealing with applicants for privileges of land occupancy, constructing and maintaining improvements, and handling personnel, including on occasion the large bodies of fire fighters that are recruited to meet emergency conditions. While all these things have to be done in connection with public forest administration and must be done in a businesslike way, they are subordinate or incidental to the technical task involved in forest-crop production and forest-soil use.

Although nearly a quarter of a century has passed since, in recognition of the technical character of the work, the national forests were placed in charge of the Department of Agriculture, it is still not an uncommon popular supposition that the Department of the Interior administers the forests; and it is sometimes assumed that, were the work of the executive departments more logically organized, the forests would be assigned again to the Department of the Interior, or to a department of public works. Such a viewpoint simply illustrates the failure of the public to grasp the real nature of our forest problem and the true character of forestry as an applied branch of scientific agriculture and a part of agricultural economics.

Yet the public mind is moving toward a practical realization that to use aright the most fundamental, extensive, and valuable of all our material resources, the soil of the country, farming, and forestry must not be separated, but must be coordinated in sound, comprehensive plans of regional development. Perhaps the most significant evidence of this trend just now is to be found in the Lake States, where lumbering and fire have worked together to convert very extensive areas of originally superb forests into almost valueless land. The agricultural development which it was long supposed would follow removal of the timber has taken place only in part, and when attempted on the poorer soils has largely failed. It is now plain that substantial parts of the three Lake States must either grow timber or be waste land, at least for a long time. A general awakening to this, and to its significance from the standpoint of local and State prosperity, is under way. Hence has arisen the idea of land economic surveys to get at the facts, as a basis for wiser public policies in matters affecting the form of land use.

Forestry an Agricultural Problem

One outcome of such surveys, it seems certain, will be to disclose clearly that in natural forest regions where a considerable part of the land is not best suited to field crops the public welfare calls for measures that will systematically promote tillage where success can be expected, and timber growing or pasturage, or both uses judiciously combined, on the rest of the land. And the whole thing is fundamentally an agricultural problem—a problem of determining in some better way than that of trial and failure, with all its economically and socially wasteful sequels, how best to utilize the soil resources. Large-scale timber growing on nonfarming land instead of impeding the development of farms actually increases both the opportunity to farm profitably and the numbers of the farm population. It furnishes local markets, additional employment, and greater local resources. Forestry and agriculture should be developed not independently and separately but jointly and with a common purpose—to obtain the utmost benefit from the land.

The extensive abandonment of tilling and the consequent decline in wealth and population in many rural districts of the Northeast are bringing a somewhat similar recognition there of what the true nature of the forest problem is and how it integrates with agriculture. In the South, with its more than 100,000,000 acres of pine land of which relatively little promises conversion into farms and from

which most of the virgin timber has been removed, like conditions are bound to develop on an even broader scale. Some of the West, too, is approaching a real problem of idle cut-over lands and land abandonment after lumbering. Throughout it will become increasingly evident that public forest policies must be shaped in close connection with the protection and advancement of agricultural interests.

Forest Experiment Stations

An important and, indeed, essential agency for making possible the best land use through forestry and agriculture, each in its right place and both working together, is forest research. Timber growing under practices that seek to obtain the best yield in quality and quantity is too new in the United States to have back of it the kind of knowledge applied by the farmer in tilling his fields. Therefore a series of forest experiment stations is being built up, one for each of the principal forest regions. Their purpose is, in a word, to do for forestry what the agricultural experiment stations have done for farming, except that they must start further back in the development of the science of forest use than was necessary for the agricultural experiment stations in their part of the field.

The establishment of forest experiment stations that fit into the series has been under way for some years. Under the terms of the McSweeney-McNary law, passed last spring, the completion of the series to a total number of 14 was authorized, and appropriations to provide and maintain the stations were authorized up to a maximum of \$1,000,000 annually. The process of building up these stations will be gradual, so that the funds required to maintain them on an adequate basis will not be needed up to the maximum authorized for a number of years; and it, of course, remains for Congress to fix the pace through actual appropriations at which the contemplated work shall go forward. Nevertheless, the prospect for the development of the art of timber growing to a point where it will compare not unfavorably with our knowledge of the best practices for growing other soil crops is greatly brightened by the new law.

Scope of McSweeney-McNary Law

The McSweeney-McNary law did much more than lay down a program for forest experiment stations. It recognized the necessity for a broad development of research under a comprehensive plan, with the cooperation of many agencies, including other bureaus of the Department of Agriculture, to the end that our knowledge of the country's forest resources, our probable requirements, and the best methods of meeting them may be commensurate with the importance of the forest in our national economic and social life. Research in methods of utilizing forest products, for example, is as essential as research in methods of production, and should be conducted in close coordination with the studies that directly concern forest conditions. In fact, no line of separation between the two fields can be drawn; the work now being done by the Forest Service at the Forest Products Laboratory is leading back to the conditions under which wood is grown, and is aiding in the development of logging practices through which forestry can be successfully applied.

Primarily because of a relatively easy fire season in the summer of 1927, the expenditures for national-forest administration, protection, and improvement during the fiscal year 1928 were more than \$2,000,000 under those for the previous year. The receipts, on the other hand, were approximately \$275,000 greater. Broadly speaking, the national-forest receipts substantially balance the outlay for the administration of current business on the forests, including the business arising from forms of public use that do not yield revenue as well as those that do; while outlays for development and improvements, including those for maintaining as well as for constructing improvements, and the fluctuating but always large cost of protecting the forest resources against destruction or impairment by fire, are what the Nation puts into the national forests annually as beneficial public enterprises and properties that are being developed and safeguarded to meet the future needs.

When the forests were established they were almost entirely without facilities for their administration, protection, or use. Like any undeveloped wilderness property they necessitated extensive expenditures to develop and equip them. Protection was at a high cost in comparison with what could be accomplished, and the public got out of the forests relatively little in comparison with their value. While the expenditures made in the past have done much to remedy this condition, much remains to be done. In particular there is urgent need for a larger investment in the improvements which make possible more efficient and more economical protection.

PREVENTING THE SPREAD OF PLANT PESTS

The maintenance of plant quarantines and the control and prevention of spread of dangerous insect pests and plant diseases is one of the most important functions of the Government as related to the agricultural industry and to the public generally. The department's activities in this line have been administered by three bureaus, namely, the Federal Horticultural Board, the Bureau of Entomology, and the Bureau of Plant Industry. Prompted by the same considerations which caused me to reorganize the work in the Bureau of Chemistry, and continuing the policy of separating the regulatory and research work, I requested Congress to establish a new unit in the department, to be known as the Plant Quarantine and Control Administration, to take charge of all functions concerned with plant quarantines and the control and prevention of spread of plant pests. This recommendation was approved and the change became effective with the fiscal year beginning July 1, 1928.

This reorganization in itself will not require any increase in expenditures and it is believed that the centralization of responsibility will result in increased efficiency in the administration of the quarantines and control operations. Under this arrangement the Federal Horticultural Board is abolished and all its functions are transferred to the new administration, together with the regulatory and control operations directed against the gipsy and brown-tail moths, Japanese and Asiatic beetles, the European corn borer, and the Mediterranean fruit fly which have been conducted by the Bureau of Entomology, and also the enforcement of the white-pine blister-rust quarantine, the detailed administration of which has been under the

Bureau of Plant Industry. In order not to lose the advantages of having matters pertaining to quarantines and their establishment considered by a group, an advisory Federal Plant Quarantine Board composed of five members, four of whom will be selected from existing bureaus in the department, has been established.

Additional Authority to Enforce Quarantines

The protection of the agricultural interests of the country through the more effective enforcement of plant quarantines has been strengthened by an important amendment to the plant quarantine act. This amendment authorizes agents of the department, when they have reason to believe that articles are moving in violation of any of the Federal plant quarantines or restrictive orders, to stop and without warrant to inspect, search, and examine persons, vehicles, receptacles, boats, ships, or vessels, and to seize, destroy, or otherwise dispose of articles found to be moving or to have moved in interstate commerce or to have been brought into the United States in violation of any quarantine order promulgated under the plant quarantine act. Such authority has been greatly needed, and its addition to the powers of port inspectors and road station officers will enable them more effectively to prevent the importation and dissemination of plants or plant products infested with pests and diseases.

Mexican Fruit Worm Eradication

One of the most important accomplishments of the year was the apparent elimination of the Mexican fruit worm from the lower Rio Grand Valley of Texas.

The pest concerned has been responsible for heavy losses in Mexico, and similar fruit flies have proven disastrous to citrus-fruit production in Hawaii and other fruit-growing sections of the world. The discovery of the insect in Texas in 1927, therefore, caused the greatest concern. Energetic clean-up measures were immediately instituted under the leadership of the specialists of the department and of the State of Texas, and these appear to have been successful in eliminating it from the area. No specimens have been taken since June, 1927, and the crop of the season of 1927-28 is apparently entirely free from infestation.

The eradication method employed was outlined in my report of last year. It consisted (1) of the destruction during the summer of 1927 of all susceptible ripe and ripening fruit throughout the two counties infested; (2) of the maintenance of a starvation period from June to September, inclusive, in which no such ripe fruit was permitted to exist in the region; and (3) of a plan of continuous inspection of the local citrus groves and fruit, carried out under the authority of Federal and State quarantines during the shipping period from October to February. This program was followed in March, 1928, by another starvation period during the spring and summer of 1928, when host fruits ripening at this time were eliminated. It is expected to continue these means of eradication for the permanent protection of the fruit industry of the United States.

The Texas counties involved have become, in recent years, one of the leading grapefruit and orange-producing areas of the country.

According to a survey by department inspectors, 3,419,157 citrus trees are growing there, of which 477,202 have reached bearing age. The shipments of citrus fruits from this region are increasing rapidly and, for the fiscal year 1928, totaled more than 1,700 carloads, distributed to all parts of the United States. The permanent establishment of the Mexican fruit worm would, therefore, have constituted a menace, not only to an important local horticultural industry, but to all other fruit-growing sections, especially of the South, which might be reached by commercial shipments of the fruits attacked.

The apparent eradication of the pest is an achievement which demonstrates the tremendous advantage of a prompt attack on newly introduced insects and plant and animal diseases. If elimination from the area proves to be complete, duplicating similar accomplishments with respect to the foot-and-mouth disease, the pink bollworm in eastern Texas and Louisiana, and the citrus canker in Florida and adjoining States, encouragement will be given to such efforts in similar emergencies in the future.

Unfortunately, in this case, the dangers of reintroduction and reestablishment are so great that controls over the production and distribution of citrus in the region must be continued in future years, at least until the insect is eradicated on the Mexican side of the river and infested fruit from the interior is prevented from reaching the Mexican towns along the border. Much has already been accomplished along these lines, due to the active and hearty cooperation of the Mexican officials and the local residents.

Cotton Pink Bollworm

In December, 1927, the pink bollworm of cotton, which had been eradicated from extensive areas of eastern Texas and Louisiana some years ago, was discovered to have been reintroduced into the main Cotton Belt at a different point, namely, the western extension of continuous cotton culture in west-central Texas.

The serious nature of this discovery was at once appreciated and every available resource was employed to meet the situation. Scouting crews assigned to determine the limits of the infestation found seven Texas counties involved, namely, Andrews, Dawson, Ector, Glasscock, Howard, Midland, and Martin, growing nearly 400,000 acres of cotton. State and Federal quarantines were promptly extended to cover the region to prevent such spread as might otherwise occur with shipments of cottonseed and other products. Preliminary eradication measures were at once instituted, including sterilization of all seed before planting, clean-up operations around oil mills and cotton gins, tracing the movement of seed and lint for the past three years, and destroying such seed as had been moved out of the area and was still obtainable.

The most effective feature of the program which resulted in the total eradication of this insect from eastern Texas and Louisiana during the energetic campaign waged from 1917 to 1921 was the establishment of noncotton zones. The raising of cotton in the regions found infested at that time was prohibited for a period of from one to three years, the growers' losses being reimbursed from State and Federal funds. This plan proved completely successful

and was recommended by the department for adoption in the present instance. The State of Texas was, however, without funds, could not participate in meeting such costs for the crop of 1928, and could make no provision therefor until the next meeting of her legislature in 1929. In view of the gravity of the situation, Congress, by a joint resolution passed in May, authorized for this crop year full compensation from Federal funds to cover cotton growers' actual and necessary losses due to prohibition of the growth of cotton in such zones. The appropriation which followed this authorization measure was included in the second deficiency act for the fiscal year 1928 and provided that the funds appropriated would not be available for the crop of 1928 unless the State contributed one-half of the cost.

FEDERAL-AID ROAD CONSTRUCTION

The Federal-aid road work of the year resulted in the initial improvement of 8,184 miles and the completion of advanced stages of improvement on 2,014 miles, the latter including the surfacing of roads previously graded and drained, the elimination of grade crossings, and other work designed to improve the quality of the service afforded.

Since the beginning of Federal cooperation in 1916 the work done, including that of the past year, has resulted in the improvement of 72,394 miles, all of which, except a limited mileage built prior to 1921, is in the Federal-aid highway system. A portion of this improved mileage is now undergoing further improvement by the process of stage construction, and such subsequent improvements have effected reductions in distance of 34 miles. For these reasons the improvements classified as completed at the close of the year aggregated 71,074 miles.

At the close of the fiscal year initial improvement was under way on 9,494 miles and stage construction was in progress on 1,285 miles.

The 8,184 miles of initial improvement completed during the year included 8,130 miles of roads and 54 miles of major bridges ranging in length of span and approaches from 20 feet to over 3 miles.

The initial road improvements consist of the construction of 2,182 miles of graded and drained earth roads, 844 miles of sand-clay roads, 1,836 miles of gravel roads, 92 miles of water-bound macadam roads, 464 miles of bituminous macadam roads, 136 miles of bituminous concrete pavement, 2,533 miles of Portland cement concrete pavement, and 42 miles paved with brick.

For each project the type of improvement is chosen to meet the present and probable future demands of traffic, modified to a certain extent by the desirability of extending some degree of improvement as rapidly as possible with the funds available to the entire system.

The latter consideration accounts for the extensive mileage of graded earth and sand-clay roads built as initial improvement. As these roads develop in traffic importance, they are further improved by stage construction. During the past year nearly 1,500 miles of previously constructed earth roads have been surfaced in this manner.

but although the year's initial construction of earth roads was 2,182 miles, the mileage of this lowest type was increased during the year by only 685 miles.

The large mileage of bridges completed is an especially gratifying feature of the year's work. With their approaches, the new bridges have an aggregate length of 54 miles, and there have now been built with Federal aid bridge structures and approaches of an aggregate length of 222.5 miles.

Construction of Toll Bridges

The use of Federal funds for payment of half the cost of large bridges offers a partial solution of the difficult problem presented by the urgent need of many such structures on the important highways and the limited State and local revenues available for their construction. Deficiency of public revenues for this purpose has resulted during the past several years in the construction of numerous important bridges by private builders under franchises authorizing the collection of tolls. Many such private toll bridges have already been built or authorized on the Federal aid highway system, thus defeating in a measure the clear intent of Congress, as manifested by the Federal highway legislation, that the roads upon which Federal funds are expended should thereafter be freely opened to public use.

The department has done everything in its power to discourage the erection of these private toll structures and, as an alternative measure, it has urged the use of the available Federal funds to an increasing degree for this purpose; and it is distinctly gratifying, therefore, to report a very substantial increase in the number of Federal-aid bridges planned and completed.

Roads in the National Forests and Parks

The work of road construction in the national forests has two principal objects. The first is the improvement of the main highways that cross the forest areas and connect communities within and adjacent to them. The second is the building of roads and trails required for the administration, protection, and development of the forests.

Toward the attainment of the first object a definite program of construction has been agreed upon following conferences with State and local officials. The program involves the ultimate improvement of a system of forest highways, including 13,911 miles, correlated with the Federal-aid and State highway systems, and work is progressing as rapidly as the somewhat limited funds will permit.

Up to the close of the fiscal year 3,775 miles of these main highways had been improved, 281 during the last year.

The improvement of these roads is an obligation the Government owes to the States in which the forests are located and to the increasing numbers of interstate travelers. The forest areas are large and numerous. They are not taxable by the States; and, especially in the Western States, they are so located that they must be traversed by all who travel any appreciable distance.

In providing for the improvement of the main transforest arteries with Federal funds the Government has recognized this obligation and has made very considerable progress in discharging it, although it is not keeping pace with the improvement of connecting roads outside the forest areas.

It so happens that many of the national parks are completely surrounded by national forests, or practically so. Access to the parks by highway is furnished in many cases only by forest roads, and the greatly increased volume of motor travel to the parks will not be accommodated adequately until these roads are satisfactorily improved.

This need has been recognized and the utilization of the park areas is being facilitated by the correlated improvement of the approach highways and the interior park roads. By an advantageous interdepartmental agreement the Bureau of Public Roads of this department has undertaken to advise and assist the National Park Service of the Department of the Interior in surveying, planning, and constructing roads in the parks. As the same bureau also supervises the Federal-aid and forest road work it is able to effect a desirable correlation of all improvement projects.

Highway Research

Encouraging progress has been made in the development of methods of improving light-traffic earth and gravel roads with asphaltic oils, and thus producing at low cost road surfaces capable of carrying traffic the year round with a minimum of mud and dust. The methods, which have been tried and improved by the Bureau of Public Roads in cooperation with the highway departments of California and South Carolina, are applicable to the thousands of miles of rural roads on which traffic is so light as to preclude the construction of more expensive surfaces, and on this account are of special importance to agriculture.

When applied to crushed-gravel roads, of which there are thousands of miles in the Western States, these methods not only eliminate the dust which has become an intolerable nuisance, but effectively prevent the wearing down of the surface, which in some cases has amounted to $1\frac{1}{2}$ inches a year. The annual loss from this cause has amounted to as much as \$1,000 a mile. The cost of the treatment which accomplishes these results rarely exceeds \$1,700 a mile and the treatment will apparently be effective for several years.

Other current highway researches deal with the classification of soils according to their suitability for road foundations and methods of treating unsuitable soils to improve their supporting capacity; with the qualities of road-surfacing materials and the design of the various types of surfaces; and with the economics and efficiency of construction methods.

Economies in method and material shown to be possible by these investigations are repeated time after time on the thousands of miles of road constructed each year and, thus multiplied, return to the public a large saving out of all proportion to the comparatively small expense of the research which makes them possible.

Corn-Borer Control

One of the most promising methods of controlling the European corn borer is the destruction of the borer by mechanical means. A relatively simple low-cutting attachment for corn binders has been

developed which cuts the stalk off at the surface of the ground. When the binder so equipped is used to harvest corn for silage or fodder very good control of the borer is obtained. In collaboration with the manufacturers, improvements have been worked out on attachments for plows which make possible the covering of cornstalks much more effectively than can be done with plows without such attachments. Much study has been given to the problem of removing cornstalks from the fields that are to be planted to small grain, better devices for cutting stalks have been worked out, and in collaboration with the manufacturers, rakes more efficient than those now in common use are being developed. Considerable progress has been made in the design of a mobile burner for destroying the borer in stalk fields. Apparently this device may have considerable application in controlling other insect pests.

Crop Machinery

The cost of harvesting grain and other crops with the combined harvester-thresher depends in considerable measure upon the design of the mechanical parts and their adjustment in operation according to the kind and the condition of the crop, to conserve power, prevent breakage, and reduce losses of the grain; and upon the care given to the machine when not in use. Studies of these features previously made in harvesting wheat in the Great Plains States have been supplemented in the past year by studies of the harvesting of soy beans and grain sorghums in the middle Western and Eastern States.

The common practice of ginning cotton as picked results in considerable losses from ginning wet cotton, which causes injury to the lint. After studies had shown that moisture amounting to $2\frac{1}{2}$ to 5 per cent of the weight of the raw cotton should be removed, various experimental units for artificial drying were made and tested. One full-sized unit was constructed and it dried some 60 bales in 1927. The results obtained indicate that the dryer is practicable and that its common use would make possible more rapid harvesting of cotton.

Drainage Investigations

Foreknowledge of the approximate results that farm drains will give in any particular soil depends as yet upon experience in similar soils in the same locality, for some of the influential factors have not been determined and evaluated. Therefore, studies have been begun of the effects of the various physical characteristics of soils in their relation to the movement of soil water in order that correct methods of drainage may be determined without tedious and costly experimentation in each new locality.

Measurements of the amount of erosion from experimental plots on moderately sloping hillsides show a measureable depth of soil removed by each storm, and that the rate of erosion varies greatly with the kind of crop and method of cultivation. The extension workers of many State agricultural colleges are using the results of the department's studies on design and construction of terraces.

Irrigation Investigations

The irrigation requirements of arid and semiarid lands in the Missouri and Arkansas River Basins are set forth in a late publication by the department.

Duty-of-water studies are being prosecuted in southern California in cooperation with State and local interests. Comparative measurements of evaporation losses from standard experimental tanks and one of 85 feet diameter show that the rate of evaporation from a small tank is greater than from a large reservoir. Studies on delivery of irrigation water and canal management have been made, and the results published during the last year. The control of gravel and silt in irrigation channels and reservoirs, the reclamation of alkali land, and the economic problems of pumping for irrigation are other subjects that have been studied.

STATE EXPERIMENT STATIONS

Cordial relationships are maintained with the State experiment stations through the department's administration of the Federal acts appropriating funds for research at these stations. In this work the department seeks to develop cooperation and community of interest. It refrains from arbitrary supervision of the work, but scrutinizes the research as regards definiteness of purpose, the relation of new projects to established knowledge, the essentials of procedure, and the adaptation of studies to the ends in view. Care is taken to guard against duplication of effort and the collection of scattered information without adequate consideration of the requirements.

Three years' work at the State experiment stations under the Purnell Act has revealed certain favorable tendencies in research in this field. One is a stimulus given to cooperation among the stations and with the Department of Agriculture. Another gain is improvement in the planning of research. There is greater definiteness of plan and also more care in selecting manageable subject matter. More emphasis is placed on improved technique in analyzing data. This is particularly noticeable in studies in which the department and the stations cooperate.

Cooperation between the department and the State experiment stations in the study of common problems has resulted in a comprehensive national system of agricultural research. These cooperative enterprises are under the general charge of joint committees from the department and the stations. Every station is represented in this cooperative work, there being nearly 900 definite agreements, besides a number of less formal cooperative understandings. The work covers a wide range, but is especially active in the study of the distribution and marketing of farm produce, rural social organizations, rural home management, vitamins in relation to human nutrition, and quality and palatability of meat.

EXTENSION SERVICE

Funds for cooperative extension work from all sources for 1928 amounted to \$20,952,560, an increase of about \$800,000 over the previous year and of \$1,800,000 over 1924. The increase for the

most part was from State and county funds, indicating an increasing local appreciation of extension activities. Of the 5,161 persons employed on the cooperative extension staffs of the 48 States on June 30, 1928, 3,675 were resident county workers, an increase during the past four years of 248. Of these, 2,318 were county agricultural agents or assistant agents, 941 were home demonstration agents, 145 were engaged in boys' and girls' club work, and 271 in negro extension work. The staff of full-time and part-time specialists numbered 1,004, an increase of 134 over 1924. Of this increase 31 were extension foresters. The employment of extension foresters by the States has developed largely because of Federal cooperation under the terms of the Clarke-McNary Act, approved June 7, 1924. As more than one-third of the total land in farms in the United States is woodland or woodland pasture, the importance of farm-forestry extension in assisting farmers to develop these lands most profitably is readily apparent.

Public appreciation of and interest in the further development of extension work was evidenced during the year by the passage of several acts by the Seventieth Congress. Foremost of these is the Capper-Ketcham Act, approved May 22, 1928, which authorized an additional annual appropriation of \$20,000 to each of the States and to Hawaii for cooperative extension work, this total of \$980,000 to be increased by \$500,000 the succeeding year. The additional \$500,000 is to be divided among the States and Hawaii, in the ratio that the rural population of each bears to the total rural population of the United States and Hawaii, on condition that an equal amount of funds from within the State be expended for extension work. The primary purpose of the Capper-Ketcham Act is to provide funds for the employment of additional county extension agents, particularly for the further development of home demonstration and boys' and girls' club work. The initial appropriation of \$980,000 for the fiscal year 1929 was included in the second deficiency act.

In the agricultural appropriation act for 1929, the supplemental Smith-Lever appropriation was increased from \$1,300,000 to \$1,580,000. This act also contained an appropriation of \$400,000 to assist States and counties flooded in 1927 to employ extension agents to aid in the more rapid rehabilitation of these areas. An act approved May 16, 1928, extended the provisions of the Smith-Lever extension act and the several experiment station acts to Hawaii, and extension work will be begun there during the coming year, in cooperation with the University of Hawaii.

Twenty-two Educational Films Made

During the year, 22 new educational motion-picture films on agricultural subjects were completed, totaling 30 reels and representing work of nine of the bureaus of the department. Notable among the new films were those on the cooperative marketing of livestock, the agricultural outlook, the use of airplanes in boll-weevil control, terracing, boys' and girls' club work, control of rats and pocket gophers, and two entitled "The Forest—and Health" and "The Forest—and Wealth." The department now has more than 2,000 copies of its films available for circulation, from which more than 8,000 loan shipments were made during the year. Colleges, farm organizations, foreign

governments, and other agencies have purchased at least an equal number of copies. It is estimated that during the year 10,000,000 people saw one or more of these films.

Department exhibits were presented at 65 fairs and expositions, in many cases these exhibits consisting of a carload or two carloads of specially prepared material. The showings included 33 State and interstate fairs and the Third World's Poultry Congress. At this congress, which was held in Ottawa, Canada, July 27 to August 4, 1927, two carloads of exhibits were shown, portraying the importance of the poultry industry in the United States and illustrating some of the major findings of the poultry experiments of the department and the State experiment stations. An exhibit is now in preparation for showing at the Ibero-American Exposition, to be held in Seville, Spain, in 1929.

Rehabilitating Flood Areas

Rehabilitation of the lower Mississippi Valley flood area proceeded rapidly during the year, material for reconstruction and re-furnishing of homes and seed and feed necessary for crop production being furnished by the American National Red Cross to those who were unable to finance expenditures for these purposes from their own resources. Agricultural extension agents employed by this department and the State colleges of agriculture cooperated with Red Cross relief officials and with local committees in working out agricultural programs for the flooded area. They located suitable supplies of seed, urged the planting of truck crops in certain areas to provide quick returns, aided in the marketing of these crops, and otherwise assisted greatly in the prompt recovery of this region. Wherever land emerged from the flood early enough for planting and was not reflooded in 1927, satisfactory crops were produced. The Red Cross furnished planting seed in the spring of 1928 to farmers who were unable to produce crops the previous year because of late planting or repeated flooding. Assistance was also given to farmers in the area flooded by the White and St. Francis Rivers in Arkansas in 1928.

Everywhere throughout the area attention was given to the use of improved seed of adapted varieties, to the growing of forage crops, to increasing the acreage of legumes to the introduction of improved livestock, including poultry, to the planting of home gardens, and to the preservation of surplus fruits and vegetables for use when fresh supplies are not available. Many thousands of packages of garden seeds of varieties suitable for a family garden were distributed by the American Red Cross both in 1927 and 1928. The result of these activities is that the lower Mississippi Valley now is planted to better seed and has more gardens than ever before, while in other respects its farms, except such as have been subject to later overflows, are nearly back to normal. This prompt recovery is due primarily to the resolute spirit of the people, to the prompt and effective aid given by the American Red Cross, and to the planning, supervision, and untiring service of men and women extension workers throughout the area. A special appropriation by the Congress available in May, 1928, provides for the continuance of extension agents throughout the flooded area during the fiscal year 1929, where

such agents can not be maintained by local agencies, and for the employment of additional agents to aid in rehabilitation.

On November 3 and 4, 1927, torrential rains over New England and eastern New York caused unprecedented floods there, especially in Vermont and in the Connecticut Valley. While the property damage was largely to factories, mercantile establishments, railroads, roads and bridges, farmers in the fertile valleys suffered heavily, particularly along the Winooski, Missisquoi, and Lamoille Rivers in Vermont. The sudden rush of flood waters down these narrow valleys carried everything before it. Known loss of life in New England was 88, of whom 48 perished in the Winooski Valley. Property damage was estimated at upwards of \$32,000,000, with \$1,500,000 agricultural loss and \$7,500,000 damage to roads and bridges in Vermont alone. The American people promptly responded to the appeal of the Red Cross for aid, and assistance was quickly rendered by that organization.

WORK OF THE WEATHER BUREAU

Among the major activities of the department, the benefits of the well-known weather service extend to almost every industry and activity of the Nation. Every year adds to the number of persons who learn how to use the weather forecasts, crop reports, and warnings of frosts, cold waves, storms, floods, and hurricanes to their personal advantage or the better management of their industries or business operations. This is particularly true of the farmer. A dozen years or more ago his rural location cut him off to a large extent from the immediate receipt of useful weather advices and bulletins. Radio, however, now changes all this and "listening in" two or more times daily the farmer is able to get practically all the current weather news as readily and completely as his city neighbors.

One of the first lines of work organized by the Weather Bureau at the time of its creation in 1871 was the systematic collection of observations from the rural and farming communities for establishing the climate of the United States. It now has more than 50 years' observations of this character from many stations, as distinguished from the observations made in the cities by the relatively small number of commissioned employees. These 50 years and more of observations from the rural communities are of inestimable value in establishing the climatic characteristics of the different sections of the United States, either for agricultural, industrial, hygienic, or resort purposes. The country at large is indebted to the farmer and to rural residents for the contributions they have made in the form of daily meteorological observations furnished to the Weather Bureau. The Government supplies a few simple instruments and instructions, and day by day the farmer, without compensation, systematically makes and records the simple observations required. For many years the number of these public-spirited citizens of the rural communities has exceeded 3,000 and at times even 4,000.

These observations over the continental United States, and like observations by citizens of other nations provide very complete climatic data for much of the land area of the world. A somewhat similar service has existed through the cooperation of shipmasters

sailing the oceans of the globe, who every day on each voyage make certain weather observations at sea, and mail copies of their reports to the Weather Bureau on reaching port, necessarily a long time after the observations have been taken.

International Action Taken

During the past year, owing to the possibilities afforded by radio, a concerted international action has been taken to effectively organize the making of simultaneous observations over the oceans of the globe, such reports to be furnished coastal stations in the best position to receive them and thus make almost instantly available simultaneous observations from all parts of the world, such observations being coordinated with like telegraphic reports received from continental stations. These reports, like the mail reports and the cooperative reports from the rural observers, are in the main made without cost except for telegraphic transmission, and it is not too much to say that the extensive world-wide cooperation between all nations concerning meteorological matters promises to be one of the agencies by which the peoples of the earth are being brought closer and closer into cooperation and acquaintance, without rivalry and with the ultimate result of greater harmony and mutual appreciation.

The extension of the work of the Weather Bureau to serve aviation and transoceanic flights was very great during the past fiscal year, and the department is exerting itself to the utmost limit of funds available to cooperate with the increasing number of air-transport organizations and supply the most complete and effective meteorological service possible.

PROGRESS IN HOME ECONOMICS

Signally useful work has been done in the last few years by the department's Bureau of Home Economics. Both producers and consumers have obtained from the bureau vital information concerning the utilization of agricultural products, the relation of many kinds of foods and textiles to health and standards of living, and the possibility of introducing improvements in producing, selling, and buying. The research program of the bureau, although not yet covering all requirements, is extensive and constantly being made more practical.

One of the principal branches of the bureau's work is the study of family dietaries. An analysis of approximately 3,000 family dietaries is now under way and should yield valuable data. Dietary scales and standards used by various investigators have been revised and a new double scale proposed. In addition a short-cut method for calculating the energy, protein, and mineral value of diets has been developed. The final results of these studies, in addition to showing kinds and quantities of food consumed, will indicate their value in terms of energy and nutrients needed for health and well being. During the last year new figures on the chemical composition of fresh fruits have been published. These figures, besides being generally useful to producers and consumers, furnish dietitians and physicians with more accurate data for calculating special diets.

Improved household methods of cooking beef and lamb have been presented in popular form. Wide attention has been drawn by the

bureau to the use of the meat thermometer. This aid to scientific cooking has aroused interest among hotel and restaurant managers as well as among home makers because it insures uniform results, and prevents overcooking and loss of weight and flavor.

Effective ways of using cotton textiles for clothing and household purposes have been described and illustrated. Designs developed for various types of children's clothing, research on starches and other materials for fabric finishing, and the study of washing temperatures have furnished much-needed facts for home makers.

Study of textiles has thrown light on the possibility of finding new uses for cotton. Osnaburg, a fabric made of low-grade cotton hitherto utilized chiefly for industrial purposes, was found suitable for window curtains, bed covers, and other household furnishings. A survey showing the extent to which cotton and other textiles have been used proved valuable to the cotton trade as well as to consumers. Another survey on trends in home sewing showed the number and types of garments made at home and analyzed the main problems of the home seamstress. Studies on the use of time by home makers have thrown light on the need for home labor-saving equipment and indicated other ways of saving the home-maker's time. These studies, together with those demonstrating the value of household budgets, should promote substantial progress in the technic of home making.

THE PRESS SERVICE

Extensive publicity is obtained for the department's work through the press. In the last year requests from newspapers and newspaper syndicates for the regular and special information services issued by the department's press service increased materially. During the fiscal year ended June 30, 1928, the press service issued 934 regular mimeographed releases, 33 special articles, 125 bulletin reviews, 37 statements by the Secretary, and numerous statements by department officials. Agricultural feature articles were also furnished to the large press associations as well as to many farm publications. These articles, many of them illustrated, constitute a valuable means of communication with the public. A special effort has been made in recent months to make news photographs of department work, and excellent results have been obtained in the press. Graphs and maps prepared in the press service are also being supplied to newspapers. Through the foreign-language information service the department places much information in the foreign-language press. In 1927 the foreign-language information service issued 234 of the department's releases, which were printed 2,057 times. One specially prepared article was used by 117 foreign-language publications. Three thousand country weeklies and semiweeklies received a weekly release called "Page, Line, and Paragraph," which is extensively used. Agricultural college editors publish much material sent them by the press service. Press correspondents and press associations in Washington demand increasing commodity information. Such information is furnished through the press service on the basis of cable reports and statistical and economic studies done in the Bureau of Agricultural Economics. This material is distributed largely by messenger to the press associations and correspondents.

RADIO SERVICE EXPANDED

The radio service of the department has passed its experimental stage and become an established and valuable part of the department's facilities for carrying the results of its work to the Nation. During the last year educational programs of the department reached the listening public from 149 broadcasting stations. These stations devoted in the aggregate more than 1,000 hours each month to broadcasting of information from the department. At prevailing commercial rates this broadcasting time would command more than \$500,000. Forty-six broadcasting stations cooperated in transmitting a special series of nine weekly releases on corn-borer control, thereby affording a good demonstration of the value of radio service in emergency educational campaigns.

Development of broadcasting networks during the year brought new opportunities of speaking direct from Washington to the farm audience. Approximately 300,000 members and leaders of boys and girls' 4-H Clubs, in addition to the usual audience of broadcast listeners, heard an evening program of the National 4-H Club camp. This program, by arrangement with the National Broadcasting Co., was transmitted through 23 stations. That company has just placed at the department's disposal a network of 15 stations which sends a 15-minute program of important current information spoken by members of the department staff to a potential audience of some 400,000 farm families each week day (noontime) except Saturday.

Evidence of growth in the number of listeners to the department's radio releases is given by an increasing demand for printed matter supplementing spoken facts. Aunt Sammy's Radio Recipes, a cook book, compiling recipes and menus sent by radio in the Housekeepers' Chat, prepared by the Bureau of Home Economics, was sent on request to 185,000 homes in the last fiscal year. Forty-five thousand booklets containing the agricultural economic lessons of the United States Radio Farm School were issued. So that listeners may set down for reference broadcast information, arrangements have been made for publication of Aunt Sammy's Radio Record for hearers of the Housekeepers' Chat, and of the United States Farm Radio Record for listeners to the farm broadcasts.

The cordial cooperation of broadcasters played an essential part in the expansion and stabilization of the radio service which took place during the last year. With a continuation of this cooperation, and with the rapid progress of the radio art generally, growth in the usefulness of radio as a means of placing facts before farmers is certain.

DEPARTMENT PUBLICATIONS

Publications to the number of 33,716,481 were distributed to the public during the year. Of this number, 13,152,367 were farmers' bulletins and 20,564,214 were miscellaneous publications—bulletins, circulars, leaflets, and bulletin lists. Compared with the distribution the previous year there was an increase of 6,000,000 copies. By far the greater part of this increase was in the distribution of farmers' bulletins and lists of farmers' bulletins.

The distribution of farmers' bulletins was greater than that for any year since 1923. Members of Congress sent out 9,065,441 copies of farmers' bulletins, the largest distribution by them since 1922. There was an increase of 1,214,013 copies as compared with the fiscal year preceding.

Substantial progress was made during the year in the indexing work of the publications of the department. To meet the needs of libraries, investigators, students, and others who require information as to what the department has published along various lines, a complete analytical index of the publications of the department for the last 25 years is in preparation. The first part of this report was embodied in the list of publications of the United States Department of Agriculture from January, 1901, to December, 1925, inclusive, which was published during the year as a miscellaneous publication.

In addition to the information available to the public in the form of printed publications there are numerous items of interest and value in the material that is mimeographed or multigraphed and distributed to those best served by this service. Thus during the year over 51,000,000 duplicated impressions or pages of this material were made available in the Division of Publications.

ADDITIONS TO LIBRARY

Additions to the department's library in the last year included 15,800 books, pamphlets, and bound volumes, and the current issues of more than 3,400 periodicals. The library now contains about 205,000 volumes. As its resources become better known outside the department, scientific workers make increasing use of its facilities. Last year 2,432 books were lent by the library to scientific workers outside of Washington. Efficient catalogues, indexes, and bibliographies make the resources practically available.

W. M. JARDINE,
Secretary of Agriculture.

FINANCIAL STATEMENT

Expenditures, Department of Agriculture, Fiscal Year 1923

Funds expended and obligated for work under the supervision of the Department of Agriculture for the fiscal year which ended June 30, 1923, including road building, totaled \$154,402,947.49, classified as follows:

(1) *Regular work*

For "regular work," or activities for which the department is directly and independently responsible, as follows:

Office of the Secretary-----	\$1,069,069.43
Office of Information-----	1,111,400.05
Library-----	84,175.00
Office of Experiment Stations-----	358,191.15
Extension Service-----	1,611,020.88
Weather Bureau-----	2,635,335.75
Bureau of Animal Industry-----	13,084,992.61
Packers and Stockyards Administration-----	385,701.74
Bureau of Dairy Industry-----	548,631.97
Bureau of Plant Industry-----	3,967,306.53
Forest Service-----	9,442,177.91
Bureau of Chemistry and Soils-----	1,111,136.55
Bureau of Entomology-----	3,174,707.34
Bureau of Biological Survey-----	986,553.85
Bureau of Public Roads-----	449,669.36
Bureau of Agricultural Economics-----	5,194,929.58
Bureau of Home Economics-----	127,187.83
Federal Horticultural Board-----	1,004,714.58
Grain Futures Administration-----	104,785.75
Food, Drug, and Insecticide Administration-----	1,356,206.94
Total expenditures for regular work-----	47,807,894.80

(2) *Other than regular work*

For work administered by department, supported by Federal funds provided as direct aid to States or for special forestry and wild-life conservation work and similar objects, as follows:

(a) *Special conservation—*

Cooperation with States in fire protection of forested watersheds of navigable streams-----	\$991,113.77
Cooperation with States in farm-forestry extension and in distribution of forest planting stock-----	129,684.96
Acquisition of lands for protection of forested watersheds of navigable streams-----	1,995,195.11
Acquisition of land for upper Mississippi River wild-life and fish refuge-----	206,163.14
	\$3,322,156.98

(b) *Colleges and stations—*

Payments to State agricultural experiment stations for research work under Hatch, Adams, and Purnell Acts-----	3,360,000.00
Payments to State agricultural colleges for extension work in agriculture and home economics under Smith-Lever Act-----	5,880,000.00
	9,240,000.00

¹ Including \$4,203,000 paid to livestock owners as indemnities for animals destroyed in connection with tuberculosis eradication, and \$5,037,041.03 for meat-inspection service.

For work administered by department, supported by Federal funds provided as direct aid to States or for special forestry and wild-life conservation work and similar objects, as follows—Continued.

(c) **Forest Service receipt funds—**

Payments to States for benefit of county roads and schools (national-forest receipts)-----	\$1, 311, 415. 89
Roads and trails for States (national-forest receipts)-----	666, 704. 79
Cooperative work, consisting of forest road and trail construction, improvements, fire prevention and suppression, disposal of brush in timber-sale operations, and investigative work (paid from private contributions)-----	1, 511, 837. 81
Refunds to users of national-forest resources of moneys deposited by them in excess of amounts required to secure purchase price of timber, use of lands, etc-----	124, 919. 58
	<u>\$3, 614, 878. 07</u>

(d) **Road construction—**

Federal-aid highways—	
Payments to State highway departments for road construction-----	82, 251, 975. 48
Highway research and investigational studies--	261, 858. 18
	<u>82, 513, 833. 66</u>
Forest roads and trails-----	7, 903, 700. 66
Mount Vernon memorial highway-----	483. 32
	<u>90, 418, 017. 64</u>

Total expenditures for other than regular work----- \$106, 595, 052. 69

Total expenditures for all purposes----- 154, 402, 947. 49

Expenditures For Regular Work

(1) *Net cost of work*

As indicated by the foregoing tabulation, total expenditures during the fiscal year 1928 for what may be designated as the "regular work" of the department (as distinguished from work supported by Federal funds administered by the Department of Agriculture, but made available for direct use by the States or for special conservation purposes), were \$47,807,894.80. Partially offsetting this amount, earnings in connection with these activities during the year, aggregating \$5,856,222.54, deposited in the Treasury of the United States to the credit of "miscellaneous receipts," and \$58,808.95 received as fees for classifying cotton and credited to the revolving fund for that purpose, make the actual net cost to the Federal Government of the department's regular work \$41,892,863.31.

(2) *Distribution by types of activity*

The total expenditure of \$47,800,000 for regular work was distributed by types of activity approximately as follows:

Types of activity	Amount	Per cent
(a) Research (including investigations and experiments in animal and plant production, breeding, and improvement, in methods of controlling diseases, insects, and other animal and plant pests, of soil and fertilizer problems, farm management practice, marketing, and crop utilization, and other scientific studies and investigations of the fundamental problems of agriculture, horticulture, forestry, etc., by means of laboratory and field experiments).....	\$11,300,000	23.7
(b) Extension work (demonstration and educational work by means of county agricultural, home demonstration, and boys' and girls' club agents and through exhibits, motion pictures, or otherwise, with a view to the dissemination, by direct contact, of the information developed by the experiments and discoveries of the department and the various States).....	2,400,000	5.0
(c) Eradication or control (direct control or eradication of plant and animal diseases, insects, and other pests, through organized campaigns, either independently or in cooperation with State agencies).....	10,200,000	21.3
(d) Service (including such activities as the administration and protection of the national forests, the weather service, crop and livestock estimating, market news service, shipping-point and terminal-market inspection service on farm products, and other work of like character for the benefit of the public, not primarily involving research or the enforcement of special laws of a regulatory nature).....	13,700,000	28.7
(e) Regulatory work (administration of some 40 regulatory laws, such as the food and drugs act, meat-inspection law, plant and animal quarantine laws, migratory-bird treaty act, cotton futures and cotton standards acts, grain standards act, warehouse act, etc.).....	10,200,000	21.3
Total.....	47,800,000	100.0

Expenditures for All Purposes, Distributed by Types of Activity

The total expenditure of approximately \$154,400,000 for the fiscal year 1928, covering all funds disbursed or administered by the department, was distributed by types of activity about as follows:

Items	Research	Extension	Eradication or control	Service activities	Regulatory work	Road construction	Total	
							Amount	Percentage of grand total
Regular work, or ordinary activities of department	1 \$11,300,000	\$2,400,000	\$10,200,000	\$13,700,000	\$10,200,000	-----	\$47,800,000	31.0
Special forestry and wild-life conservation	2 48,600	3 54,700	-----	4 3,218,700	-----	-----	3,322,000	2.2
Colleges and stations (payments to States under Hatch, Adams, Purnell, Smith-Lever, and supplemental acts)	5 3,300,000	6 5,880,000	-----	7 3,064,000	-----	-----	9,240,000	6.0
Forest Service receipt funds	7 556,000	-----	-----	-----	-----	-----	3,620,000	2.3
Federal-aid and forest roads	8 262,000	-----	-----	-----	-----	\$90,156,000	90,418,000	58.5
Grand total	15,526,600	8,334,700	10,200,000	19,932,700	10,200,000	90,156,000	154,400,000	100.0
Percentage of grand total	10.0	5.4	6.6	13.0	6.6	58.4	100.0	-----

17.3 per cent of grand total

2 Forest taxation and timber insurance studies, under appropriation "Forest fire cooperation" (Clarke-McNary Reforestation Act).

3 Cooperation with States in farm forestry extension work (Clarke-McNary Reforestation Act).

4 Cooperation with States in forest fire protection and distribution of forest planting stock, under Clarke-McNary Reforestation Act; purchase of forest lands, under Weeks forestry law and Clarke-McNary Act; and purchase of lands for Upper Mississippi River Wild Life and Fish Refuge.

5 Payments to State agricultural experiment stations for research work, under Hatch, Adams, and Purnell Acts.

6 Payments to State agricultural colleges for extension work under Smith-Lever Act.

7 Forest investigative work, under appropriation "Cooperative work, Forest Service."

8 Expended for county road and school purposes in national-forest States, forest improvement and protection, and other forestry purposes.

9 Highway research and investigational studies, under appropriation for Federal-aid highways.

Income From Department's Activities, Fiscal Year 1928

Incident to the department's work during the fiscal year 1928, direct receipts totaling \$8,558,378.34 were covered into the Treasury and fines were imposed and judgments recovered by the courts amounting to \$129,658.29 in connection with the enforcement by the department of the regulatory laws which devolve upon it for administration and execution, as follows:

(1) *Receipts*

(a) Deposited to credit of miscellaneous receipts fund:

Regular work—

From business on the national forests-----	\$4, 900, 922. 89
From other sources-----	955, 299. 65
	<u>\$5, 856, 222. 54</u>

Other than regular work—

10 per cent of net receipts from business on the national forests, appropriated as a special fund for forest road and trail construction in 1929-----	540, 511. 91
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Proceeds from sale of surplus war materials transferred to States for road-construction work-----	46, 172. 06
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Contributions from private co-operators, appropriated as a special fund for road and trail construction, fire prevention and suppression, brush disposal, and investigative work on national-forest and privately owned lands-----	1, 550, 849. 12
	<u>2, 137, 533. 09</u>

Total deposited to credit of miscellaneous receipts fund---- \$7, 993, 755. 63

(b) Deposited to credit of applicable funds of department:

Fees collected for classifying cotton, deposited to credit of revolving fund for conducting that work-----	\$58, 808. 95
Reimbursement to various department appropriations for expenditures made therefrom-----	505, 813. 76

Total deposited to credit of department funds----- 564, 622. 71

Total receipts----- 8, 558, 378. 34

(2) *Fines*

Fines imposed and judgments recovered by the courts in connection with violations of statutes intrusted to Department of Agriculture for enforcement-----

129, 658. 29

Total direct income from activities of Department of Agriculture-----

8, 688, 036. 63

DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL ECONOMICS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF AGRICULTURAL ECONOMICS,
Washington, D. C., September 17, 1928.

SIR: I have the honor to transmit herewith a report of the work of the Bureau of Agricultural Economics for the fiscal year ended June 30, 1928.

Respectfully,

NILS A. OLSEN,
Chief of Bureau.

HON. W. M. JARDINE,
Secretary of Agriculture.

The Bureau of Agricultural Economics was under the direction of Lloyd S. Tenny, as chief of the bureau, until he resigned on July 16, 1928.

During the past year the activities of the bureau have been strengthened along a number of important lines, in order to meet the increasing demand for economic information and services. Much effort has been devoted to furnishing information of assistance in remedying maladjustments in farm organization and agricultural production. Requests have been frequent for assistance in planning improved systems of agriculture in districts where changed conditions have made the old order unprofitable.

In an effort to bring about a better adjustment of production to market requirements, the agricultural outlook reports have been materially expanded and improved. The outlook report issued in February, 1928, summarized in brief form the situation with regard to each crop and pointed out the probable trends of supply, demand, and prices during the coming year. A number of State agencies cooperated with the bureau and published further detailed information showing the application of the outlook report to their particular States and localities. Supplementing the outlook reports, the "intentions to plant" reports are issued just previous to planting time,

both in the spring and fall, and the pig surveys, showing farmers' intentions to breed pigs, are issued twice a year. In addition, a pamphlet covering current developments in the agricultural situation is published once a month. Congress recognized the need for strengthening the outlook program and in the appropriation act for the fiscal year 1929, included a substantial increase with which it will be possible to organize the work much more effectively during the coming year.

The bureau has worked in close cooperation with farmers in putting such information to practical use. Farmers have been assisted in finding the most profitable combination of farm enterprises under varying conditions. Many sections have reorganized their farm activities on a more profitable basis as the result of recommendations made by this bureau. State and local agricultural workers have joined the bureau in this work.

The reinforcement of the commodity and general market information service has been no less marked. Although there has been no material expansion of resources for these activities, it has been possible through reorganization and coordination of the services to furnish a greatly increased volume of pertinent information on current economic conditions. Particularly significant has been the growing demand for

economic interpretations of available data. The bureau has striven to meet this demand through a wide range of research studies and through its current summaries and monthly market situation reports. It should be remembered that the volume of statistics covering farm commodities is so large, and the factors affecting future prospects and farm incomes are so numerous and complex, that thorough analyses of the data must be made by those skilled in interpreting such data if they are to be of practical use to producers.

The foreign service of the bureau is a vital factor in its program. Although supplied with only a limited number of outposts in foreign countries, the bureau, working in cooperation with other departments, has been able to provide with increasing success the kind of information which producers need in the marketing of their products abroad. The bureau's marketing specialists have given very practical assistance in explaining the standards for American farm products to foreign buyers and in advising American producers and shippers regarding the tone of foreign markets and the best methods of handling products to meet the requirements of foreign markets.

The cooperative marketing act, which has now been in operation for two full years, has made possible the development of a program which has been of vital importance to farmers' cooperative associations throughout the country. The bureau is now rendering expert assistance with regard to the many problems facing cooperatives, and advises groups of farmers with regard to the possibilities and limitations of the cooperative method of marketing and purchasing.

The service and regulatory activities of the bureau, such as the inspection of farm products, and the administration of the cotton futures and cotton standards acts, grain standards act, warehouse act, and the standard container act, have carried on full programs. The experimental beef grading and marking service has met with general approval and has now been put on a fee basis. A service covering certification as to point of origin of alfalfa seed has been inaugurated and has met with much favor.

New legislation which has been put into effect includes the act providing for the publication of statistics of the grade and staple length of cotton of the carry-over and of the current year's crop. Preliminary work on the

1927 crop in two sample areas was done under the regular appropriation act during the past year. This work was very successful and indicates that the full data which will be published for the August 1 carry-over and the 1928 crop will be of great benefit to the cotton interests. An act relating to the investigation of new uses of cotton was passed late in the year, as well as an act authorizing the use of certain funds for studies of the marketing of wool and for establishing wool standards. An act providing specifications for hampers, round-stave baskets, and splint baskets, which rounds out the program of standardization of containers for fruits and vegetables, was approved late in the year. The produce agency act was effective throughout the past year, but little activity was possible until the passage of the first deficiency act, which provided funds for its administration. Eighty complaints were investigated, and 62 had been settled at the close of the year.

A point of strength in the bureau's work is the wide cooperation which is maintained with State and local agricultural workers. This makes it possible for the Federal workers to come into closer touch with local conditions and to obtain facts at less cost than would otherwise be possible, and also to reach more easily the groups of farmers for whose benefit the studies are being made. Invaluable aid was given the bureau in gathering production and market information and in making these data available to the public. The local workers assist most effectively in helping farmers to put the recommendations for improvements into practical use. Work is carried on under cooperative agreements in every State in the Union and in Porto Rico.

Detailed reports follow, which cover the work under each of the major divisions of the bureau.

DIVISION OF FARM MANAGEMENT AND COSTS

H. R. TOLLEY, in charge

The research work of the Division of Farm Management and Costs serves as a medium through which the bureau's various lines of economic information are focused upon the individual farmer's problem of what to produce and how to produce it so as to obtain the greatest profit. Information relating to market require-

ments, present and prospective demand and prices, production trends in competing regions, and production costs, methods, and practices are interpreted in the light of the conditions and factors governing successful farming in particular farming regions in such a way as to assist individual farmers and groups of farmers in determining sound production programs for their farms.

Partly as a result of the increasing commercialization of agriculture, the problem of regional competition between the farmers of different producing areas has taken on added significance in the past decade. For this reason a regional study of many farm-management problems centering around particular commodities or types of farming is necessary. The more recent work of this division includes a number of projects of this type; for example, the studies of the apple industry, of the effect of the European corn borer upon farm management in the infested areas, of the combine harvester-thresher in the Great Plains region, and of range-cattle production.

TYPES OF FARMING

Studies of types of farming in the United States have progressed to the point where type-of-farming areas have been definitely established for the three census years 1910, 1920, and 1925. Maps have been prepared for publication showing these areas and indicating the important shifts which have taken place in types of farming during the past 15 years. These maps are particularly helpful in showing the effect of the conditions during the war and postwar periods upon farming systems in various parts of the country. Special attention has been given to the changes in types of farming that have occurred in the Cotton Belt and the problems that have arisen in connection with these changes.

In cooperation with the State experiment stations detailed analyses of types of farming have been completed in Oklahoma, Michigan, and North Dakota. Particular attention was given to determining the tendencies with respect to changes in the prevailing types of farming in the different parts of the State. The results have furnished agricultural workers definite knowledge upon which to base programs for improvement. In North Dakota the data assembled were made the basis for a series of economic conferences which were largely attended

by farmers. After consideration of the facts presented to them definite programs looking toward the improvement of agriculture were outlined and adopted by the farmers and extension agencies. Similar detailed analyses of types of farming are now in progress in Texas, South Dakota, and Kansas.

FARM RECORDS AND ACCOUNTS

Studies of farm-organization and management problems by means of farm records and accounts were continued in cooperation with the State colleges of agriculture in selected farming areas in 16 States in which changing economic conditions are making adjustments necessary in the farming systems and practices.

In these studies data are obtained from carefully kept records, showing the amounts of man labor, horse work, and fertilizer and other materials used in growing the different crops, the man labor, horse work, feeds, and other materials used for the different kinds of livestock, and the prices paid by farmers for materials bought and received by farmers for the products sold in recent years. These data, together with other information, are used in outlining systems of farming that seem to offer opportunities for profits under present conditions. They also show how successful farmers have worked out profitable systems and practices.

Results have been published on studies in an irrigated section of Colorado, a dairy section of Wisconsin, a hill-land cotton section of Mississippi, a dairy, small-fruit, and tobacco section of Kentucky, a dairy section of Kansas, and a black-land cotton section of Texas.

REORGANIZATION OF FARMS

The introduction of more profitable farming systems on tobacco farms of south-central Virginia was continued in cooperation with the Virginia Polytechnic Institute. A number of farmers are now putting into practice recommendations which the department has made. In general, these farms have been reorganized so that tobacco plays a less important part in the farmers' incomes. Poultry, dairy, and hog enterprises have been expanded, and only the better tobacco fields have been planted in tobacco. More land is available for the production of feed crops, a situation which fits well with the livestock enterprises.

Studies were made, in cooperation with State agricultural experiment stations, of the systems of farming in western Montana, northwestern Indiana, the central San Joaquin Valley of California, the Salt River Valley of Arizona, and the Elephant Butte Irrigation Project in Texas and New Mexico. Analyses of production and marketing were made, and possible future returns were considered in making recommendations for changes in the present systems of farming. Farm plans were submitted to committees of farmers, and other means were taken to bring about practical results.

FARM BUDGETING

In Kentucky, North Carolina, and North Dakota, organized projects are under way in cooperation with the State colleges of agriculture in which definite farm plans are worked out with farmers who agree to put them into operation. These plans are the result of farm budgets for different systems carefully worked out and compared. These farmers keep accounts during the year, and the results obtained are compared with results that might have been obtained with other systems as shown by budget statements. In this way data are obtained which are used as a basis for modifying conclusions obtained by other research studies or for showing that these conclusions are sound and practicable. A bulletin on farm budgeting and forms to be used by farmers was published.

LOCAL APPLICATION OF OUTLOOK INFORMATION

Increasing attention is being given to the use of outlook information in determining the adjustments in farming plans which are necessary in order to obtain the greatest continuous profit. Special efforts have been directed toward cooperation with State and local agencies in localizing and interpreting the outlook reports issued by the bureau so that the information will be more directly applicable to the varying conditions which prevail in the different sections of the country. The outlook information was received with great interest by farmers and extension agents, and in many areas the holding of annual or semiannual outlook meetings where this information is presented and its significance discussed has become an established feature of agricultural extension work. Studies essential to providing farmers with more background information upon

which current interpretations of outlook information may be based were continued and expanded during the year. A moving picture setting forth the objectives and essential features of the outlook work was prepared in the bureau and has been well received.

COMBINE HARVESTER-THRESHER OPERATIONS

The studies of the use of the combined harvester-thresher in harvesting small grains were continued. Information was obtained in Illinois, Indiana, Pennsylvania, South Dakota, and Virginia in 1927 to supplement that which was obtained in the Great Plains in 1926.

In southwestern Kansas and northern Oklahoma a special study of the effect which the combine is having upon farm organization was made in cooperation with the experiment stations. This study revealed that because of the combine important changes are taking place in the size of the farm unit and in the relative importance of the various lines of production. Systems of farming which would utilize the combine and other resources of the farm most effectively were outlined for this area as a result of the study.

The results of these studies indicate that the advantages of the combine are the saving of labor, the eliminating of transient labor, the early clearing of fields for tillage operations, the distributing of the straw on the land, and the getting of the grain to market earlier. The disadvantages were found to be the large investment required, the large amount of power consumed, the greater risk from damp grain, the greater risk to crops from storms, and the difficulty of saving the straw for feed and bedding. Harvesting and threshing losses need be no greater with combines than with other methods of harvesting and usually are less. A discussion of these findings has been published and a motion-picture film prepared.

THE APPLE INDUSTRY

Studies of the apple industry were continued from last year. A bulletin covering the Indianapolis apple market was issued in cooperation with the Purdue Agricultural Experiment Station. The bulletin treats of the local and outside sources of the city's apple supply and the varietal requirements of the market. It points out the possibilities which local producers have of increasing production of specific varieties and the necessity of improving

the quality and pack of locally grown apples. A report was issued on the sources of apple supply and varietal composition of the supply of 41 important cities located in various parts of the country. Local and outside supplies were analyzed and special attention given to the outstanding reasons for the prevalence of specified varieties in each market. Studies of the prices received by growers for various varieties, grades, and sizes were continued. In cooperation with the Utah and Arkansas State Experiment Stations, special studies were made of profitable adjustments which might be made in the farming systems of the apple areas. A bulletin was issued on the factors affecting apple yields in the Cumberland-Shenandoah region of Pennsylvania, Virginia, and West Virginia, in cooperation with the State experiment stations and other bureaus of the Federal department. The physical characteristics of the region were found to be generally suitable for orcharding, although some orchards are so located that it would be very difficult to produce apples economically. In general, the major causes of low yields in the region are attributable to practices over which the farmer has considerable control. Suggestions were made for improving the management of orchards so that more economical production would be obtained. There is an apparent need for studies of profitable orchard management and adjustments in the systems of farming in a number of the apple areas.

The final aim of the study of the apple industry is to indicate adjustments that will prove profitable to the grower. The results of the research work now done along the lines indicated will be used in connection with statistics gathered on the ages and varieties of trees in commercial orchards to point out how the farmers of the different apple sections may make improvements in the operation of their business and better adjust their production to market requirements.

RETURNS TO PEACH AND STRAWBERRY GROWERS

Following the previous year's study of the general fresh peach situation in the important commercial peach-producing States, a study was made in cooperation with the New Jersey Agricultural Experiment Station of the factors which affect the returns at

New York City to peach growers in New Jersey and the Southern States. Annual, weekly, and daily supplies in New York were analyzed for the purpose of showing the quantities of fresh peaches which New York City will take at various prices. The effect of the use of cold-storage facilities on returns and the conditions under which it pays to store peaches were determined. New York's preference for specified varieties, grades, and sizes of peaches as measured by price differentials was thoroughly treated. This study yielded facts of much value to the grower and is encouraging from the standpoint of developing methods of research. Late in the year a similar study of strawberries was undertaken in cooperation with the Arkansas experiment station.

EUROPEAN CORN BORER

The establishment of the European corn borer at the northeastern edge of the Corn Belt makes it necessary for farmers in that area to adopt methods of control which are most likely to prevent or most effectively minimize commercial damage. The control practices which are necessary involve substantial changes in the usual methods of handling corn on Corn Belt farms, particularly with respect to the disposal of cornstalks, stubble, or other refuse in cornfields and the preparation of cornland for subsequent crops. In a study of the cost of the various methods of disposing of cornstalks and other refuse it was found that the amount of labor necessary varied widely in different parts of the present infested areas because of the variation in the number of acres grown per farm, the present methods of harvesting corn, and the usual means of preparing cornland for small grain the following year. Information obtained from several hundred farmers in Ohio and Michigan was used in determining the most economical methods of meeting control requirements under various conditions as found on farms in this area. A Farmers' Bulletin, *Farm Practices Under Corn Borer Conditions*, was based in a large part upon this study.

During the year data were obtained and analyzed showing the methods of harvesting corn and preparing corn ground for subsequent crops in Ohio, Indiana, and Michigan. These data indicate the areas in which various types of adjustments in methods of growing corn are necessary because of the corn borer.

One means of utilizing cornstalks and at the same time destroying the borer is to use the husker-shredder. In order to determine the conditions under which this means of meeting the problem would be desirable, a special study of the use of the husker-shredder in Ohio, Michigan, Indiana, and Illinois was made during the year. The cost of shredding as compared with other methods of utilizing or disposing of stalks, the feeding of shredded stover and the problem of storing shredded stover were all carefully considered in this study.

As a basis for more detailed analytical studies of the problem facing farmers in adapting their farming systems and corn-production methods to corn-borer conditions, a special study of types of farming in the eastern Corn Belt was inaugurated during the year.

COST OF PRODUCING STAPLE CROPS

Cost-of-production studies of corn, wheat, oats, cotton, and potatoes were continued. Reports from farmers located in many parts of the country were analyzed and the results published. The continuous collection of these data makes it possible to construct indices showing general changes from year to year in production costs. In cooperation with the Arkansas and Utah Agricultural Experiment Stations the costs of producing apples were determined. Particular emphasis was given to the various varieties grown and the economic place of orcharding in the organization of farms.

METHODS OF PREPARING JOHNSON HAY FOR MARKET

To enable farmers of the Black Prairie Belt of Alabama and Mississippi to make better use of much of the land on which Johnson grass is now grown, attention was given to the problems encountered by farmers in the production and preparation of Johnson hay for market.

Emphasis was given to market requirements for the hay of this area; to causes of low-grade hay and practices that result in the maximum production of hay of high quality. The practices followed on the more successful hay farms were determined and set forth as examples of good methods of handling Johnson hay.

RANGE-CATTLE PRODUCTION

Studies embracing the important range-cattle producing areas were con-

tinued in cooperation with the Bureau of Animal Industry and State experiment stations and extension services. The results of these studies are being used as a basis for definite recommendations to ranchmen. It has been determined that the poor returns on some ranches as contrasted with the excellent returns on others are due in most instances to the size of business being too small to provide sufficient income to meet the necessary operating expenses which are usually higher in proportion to the income on the smaller outfits. Arrangements have been made for providing ranchmen with information on the outlook for beef cattle and especially on the demand for feeders in the Corn Belt, and at the same time information on the situation in the range areas will be disseminated among the feeders.

SYSTEMS OF HOG PRODUCTION ON CORN-BELT FARMS

The previous year's study of the economics of pork production on Corn-Belt farms was continued. Particular attention was given to the conditions under which it pays to follow the one and two litter systems of production. Climatic conditions and the quantity of corn produced on the farm affect in a general way the choice of the systems of production. Corn-Belt areas typified by large farms and heavy yields of corn tend toward a greater use of the one-litter system. Although the rate of marketing hogs varies from year to year as favorable or unfavorable feeding conditions prevail, there is a relationship between the system of production and time of marketing the hogs. Spring pigs produced under the two-litter system usually are marketed during the early fall months, and pigs from the one-litter system generally are marketed during the winter. There appears to be a relationship between the system of pork production followed and the organization of the entire farm business. Attention is being given to the systems of farming that are proving most profitable with the two systems of hog production.

HOGS IN THE PEANUT AREAS OF ALABAMA AND GEORGIA

As a direct development of last year's study of livestock possibilities in the coastal plain region an economic study of farm organization in the peanut areas of Alabama and Georgia with reference to hog production was undertaken in cooperation with the Alabama

and Georgia experiment stations. A report was issued in which the relative economy of various systems of grazing and feeding hogs was set forth. The necessity of using high-quality grazing and finishing crops during the summer feeding period for increasing the gains in weight made by the animals was pointed out. Consideration was given to the most profitable size of the hog enterprise in relation to the farming system for farms of different sizes, the organization and management of the hog enterprise for the most economical production of pork, and the organization for the efficient use of labor, equipment, and by-products of the farm. The need for definite systems of hog production is so great that an effort will be made to formulate tentative systems at an early date.

POULTRY PRODUCTION

Cooperative studies of farm-management problems on commercial poultry farms in New York were continued. Special attention has also been given to the analysis of information relative to the trends of the poultry industry in various sections of the country and the significance of these trends to producers in the different areas. The importance of following farm-management practices which are essential in the production of high-quality products for which premiums are paid is indicated by these studies.

ECONOMICS OF BEEKEEPING

A study of apiary operation and management was undertaken in cooperation with the Bureau of Entomology and several State colleges of agriculture. The present study is confined to the intermountain region. Later it is planned to expand the study so as to include other regions.

The object of the study is to determine for apiaries of different types and sizes (1) the labor, power, and material requirements in honey production, (2) the kind, amount, and cost of house and apiary equipment needed, and (3) detailed plans for the organization and operation of successful apiaries. Forty apiaries are keeping careful and complete records of all operations.

SOURCES AND USES OF FARM INCOME

In cooperation with the Ohio experiment station, a study was made for the purpose of determining the conditions

of farming and of family living in a region of low incomes and low expenditures. This study is discussed under the Division of Farm Population and Rural Life.

FARM RETURNS

Voluntary reporters submitted statements of the financial results of operation for their own farms for 1927. The average return of \$1,290 shown by the reports of 13,859 owner-operators for 1927 was higher than in previous years, except 1925 when 15,330 farmers from the same general list reported returns averaging \$1,297.

The return of \$1,290 per farm in 1927 was made by farms averaging 275 acres in size, representing an investment of \$15,445 at values current on January 1, 1927, and consisted of \$1,048 excess of cash receipts over cash outlay for current operating expenses and an increase of \$242 in the inventory of crops, livestock, machinery, and farm supplies during the calendar year.

In addition, the farm family had food produced and consumed on the farm the estimated value of which on the farms reporting the item was \$273, and fuel and house rent, the values of which were not reported. On the other hand, interest averaging \$201 paid on indebtedness and outlays for improvements averaging \$141 were not included in the computation of current cash operating expenses.

Improvement in returns in 1927 as compared with returns from the farms reporting for 1926 was shown for all the geographical divisions except the East North Central States in which increases in reported receipts were more than offset by increases in cash outlay. The largest increase was in the Western States, where improvement in cattle values were specified by many reporters as contributing most largely to larger receipts and to better financial conditions at the end of the year.

Sixty-five per cent of the reports for 1927 showed returns less than the average, \$1,290. Only 8 per cent of those reporting showed net losses from operations of 1927, as compared with 14 per cent in 1922 and with 10 per cent in 1925, the most favorable year for which these reports have been assembled. About three-fifths of the returns have fallen each year in a group ranging from 0 to \$1,499; the largest single group has been that ranging from 0 to \$499.

DIVISION OF CROP AND LIVESTOCK ESTIMATES

W. F. CALLANDER, *in charge*

Increasing interest on the part of the public in crop and livestock reports and a more widespread demand for statistical information concerning agriculture has marked the year just closed. The number of inquiries received by mail, as well as by telegraph and telephone, has exceeded that of any previous year.

In order to meet this growing demand, the work has been expanded in several directions. No increase in personnel has occurred, however, the increased work being made possible through better arrangement for handling reports.

The price work has been enlarged to include a series of schedules on which prices are obtained on articles farmers buy, to be used as a better basis for an index of the purchasing power of the farm dollar. Work has been done in laying the foundation for a system of regular reports and estimates covering poultry, eggs, and milk. Marked progress has been made in estimating the annual production of livestock by States. The Washington statistical staff devoted much time to the compilation and analysis of data to be used in determining the annual income of farmers, by States.

Much time also has been given to the preparation of material for the outlook and intention-to-plant reports, both of which are receiving more widespread attention and are assisting in bringing about a better adjustment in agricultural production.

Notable progress has been made in the development of special statistical methods to be used in estimating acreage from sample data, and the forecasting of crop production and yields from weather, and other factors. The application of improved statistical technic will result in increased accuracy in the crop reports.

AGRICULTURAL PRODUCTION AND INCOME

Information has been gathered during the past two years from farmers with respect to the disposition of the principal crops grown on farms of the United States. On the basis of this material estimates have been made, by States, of the proportion of the various crops which are sold off farms. These estimates have been made a part of the statement issued by the bureau

upon the evaluation of agricultural production, and the determination of cash and gross income of farmers.

Estimates have also been completed this year of the production of meat animals and value of such production by States. In making these estimates there have been utilized data collected on carloadings and unloadings of livestock, by States, the origin of livestock received at principal livestock markets, by States, and the pig, calf, and lamb crop surveys which have been made the past few years. On the basis of the same data in a slightly different arrangement an estimate has been made of cash income and farm consumption of meat animals and meat which constitute the estimates of income. Estimates of both production and income have been completed for four years, 1924 to 1927, inclusive.

A thorough analysis has been made of all available data upon the production, consumption, and sale of dairy and poultry products for use in connection with the estimates of the value of agricultural production, cash and gross income of farmers in the United States. In arriving at these estimates the monthly inquiries on milk and eggs produced and on chicks on hand have indicated very definitely that a more accurate measure of fluctuations in annual production can be obtained from this type of data than from a single annual inquiry.

There has been a great demand for information of this character, which heretofore has been furnished only for the United States as a whole. The department, as well as a number of agencies outside the department, have in the past made attempts to break down the estimate for the United States into estimates for individual States. While there are a great many details for which adequate information is not yet available, it is felt that the estimates as they have been tentatively published represent a closer approximation of the actual income than was secured from any method heretofore used.

RESEARCH IN CROP-REPORTING METHODS

The analysis of sample data has made progress during the past year. In connection with the statistical conference held in 1928 for the field force of this division, the yield per acre sample data were analyzed for 16 different States. A start was made also on the analysis of individual farm acreage sample data. The analysis of

the acreage sample for several States has been completed and will be published as a technical bulletin. This analysis of the basic sample material has led to a better comprehension of the statistical problems involved in connection with the utilization of different kinds of sample data as a basis for estimates of crop and livestock production. Improved methods of handling current data have been developed as a result of these studies.

The study of the relationship of weather to crop yields has made substantial progress in several States. A critical analysis is being made of the relationship between monthly condition figures and final yield for the major crops in the more important States. This critical analysis shows where the present method of interpreting condition figures in terms of probable yield is satisfactory and also brings to light cases where there is little if any relationship between the condition of the crop and the final yield per acre.

The time-series analysis of crop and livestock data is fundamental to the further development and improvement of the forecasts and estimates. A great deal of this work, however, must be done by statisticians in the field offices. An adequate analysis and interpretation of changes in yield per acre from year to year can best be made by the research worker who is thoroughly familiar with the State with which he is working and in close contact with other scientific agencies within that State. For this reason it is necessary to have research men in a number of the field offices. Research studies concerning the yield per acre of crops will lead to a statistical measurement of many of the fundamental laws of plant growth. An analysis of changes in acreage or numbers of livestock will lead back to the fundamental principles of economics and psychology. It is only by such an analysis and interpretation that the science of estimating and forecasting crop and livestock production can properly be developed.

FARM PRICES

The outstanding development of the past year in the field of farm price reports is the progress that is being made in meeting the demands of the agricultural colleges for regional farm prices for use in connection with outlook projects. In Colorado, for example, this division is cooperating with the State agricultural college on

a project which will make available monthly farm prices by economic agricultural areas within the State. This necessitated a redistricting of the State into nine economic areas which differ materially from the original crop-reporting districts of the State. A similar project is under way in co-operation with the Oregon State College of Agriculture, and arrangements are pending in several other States.

Crop-year average annual prices have been computed by States for practically all farm products from 1919 to 1927. These State prices will be used in connection with the evaluation of agricultural production and income and the determination of farm income by States, and will be submitted for publication in the near future.

The farm-price reports have been materially improved during the past three years. A larger and more representative sample is now being secured. The increase in returns has been effected by only a comparatively small increase in the list of correspondents and is largely due to the monthly News Letter to Price Reporters, which has stimulated the interest of the correspondents and increased the regularity of their reports.

RURAL RETAIL PRICES

The rural retail prices collected are now being used as the basis for the Department of Agriculture index number of prices paid by farmers. This index is now used instead of the Bureau of Labor wholesale index of nonagricultural commodities for computing the purchasing power of agricultural prices and farm income. The lists of correspondents, as well as the actual returns for this inquiry, have been expanded several hundred per cent during the past year and a half, following the reorganization of this inquiry.

TRUCK-CROP REPORTS

Estimates of intention to plant, planted and harvested acreage, forecast and harvested production, prices received each month by growers and total farm value, distribution and storage, and condition of the growing crops were made on 19 crops. These estimates covered crops produced for table use and for canning and manufacture. The information used in making these estimates was obtained by 371,000 schedules mailed to correspondents on the truck-crop list and from special reports received from

State agricultural statisticians. The Truck Crop News, in which most of the 193 reports made on the above-named crops were published, together with notes regarding weather and growing conditions, was issued throughout the year.

COOPERATION WITH STATES

During the past year cooperative agreements for the conduct of the crop-reporting work have been entered into with the College of Agriculture of Tennessee and the State Experiment Station of Ohio, thus making a total of 33 States in which the crop-reporting work is carried on in cooperation with State agencies. Negotiations are pending in two or three additional States. The contributions which are made by the cooperating agencies for the conduct of this work have made it possible in recent years to greatly expand the scope of the work in a number of States and have permitted the preparation and issuance in a number of States of county estimates of crop production covering the principal crops and livestock. The fact that the State agencies are cooperating in the work is tending to increase local interest in the reports and makes it possible to reach a larger number of farmers than has heretofore been possible.

ORGANIZATION

The decentralization plan which was put into effect last year is working out very satisfactorily, particularly with respect to the estimating of acreage and numbers of livestock on farms. Under the present plan from two to three visits a year are paid to each field office by a representative from the Washington staff. Marked advantage has resulted from having all of the data relating to acreage and number of livestock in one place, making it possible to arrive at better figures than have heretofore been possible.

During the past year 2,542,000 schedules were mailed out by the Washington office and 4,500,000 by the field offices. Because of the fact that practically all of the schedules relating to acreage and livestock, including the rural-carrier surveys, are now handled by the field offices, there has been a marked increase in the number of schedules handled by the field offices and a corresponding reduction in the number sent out and handled by the Washington office.

The division acts as a service unit for a number of the research divisions of the bureau, many thousands of schedules having been sent out on inquiries relating to farm management, land economics, farm life and rural population, as well as various commodity studies. This has resulted in a marked saving to the bureau since this division has already an organization established for handling schedules expeditiously and economically.

DIVISION OF COTTON MARKETING

ARTHUR W. PALMER, *in charge*

The Division of Cotton Marketing is engaged in service and regulatory work under the United States cotton futures act, the United States cotton standards act, and the act of March 3, 1927, "authorizing the Secretary of Agriculture to collect and publish statistics of the grade and staple length of cotton," and in research and demonstrational work in related fields.

On April 12, 1928, the President approved an act entitled "An act relating to investigation of new uses of cotton," under which the Secretary of Agriculture and the Secretary of Commerce are authorized to engage in technical and scientific research in American-grown cotton and its by-products and their present and potential uses, including new and additional commercial and scientific uses for cotton and its by-products, and to diffuse such information among the people of the United States. This act will result in the further extension of the cotton-research program.

STAPLE STANDARDS

Representatives of the cotton growers', manufacturers', and shippers' associations, and of cotton exchanges were invited to Washington to witness the selection of bales of cotton suitable for original representations of the staple standards and for use in making practical forms of the standards for public distribution. A number of bales of each length represented by practical forms were selected, and the Secretary signed an order to be effective August 1, 1929, designating one bale of each length as the "original representation." It was provided that prior to the effective date of such original representations, practical forms might be prepared for public distribution which might be used as permissive standards in the purchase and sale of cotton. In-

dications are that these standards will be extensively used by the trade.

MILLIMETER DESCRIPTIONS

The official staple standards and the millimeter descriptions in use have received much attention. Misunderstandings have arisen between European buyers and United States shippers with respect to the cotton which might properly be shipped against stated millimeter descriptions. Many complaints have been made as to the outcome of arbitrations in Europe on cotton sold on these descriptions. Early in June, 1928, the American Cotton Shippers' Association submitted a written request for an interpretation of the provisions of the cotton standards act which would apply to the present use of millimeter descriptions in purchases and sales of cotton in interstate and foreign commerce. This communication was referred to the solicitor of this department, who rendered an opinion to the effect that under present usage millimeter descriptions as applied to cotton which is of or without the lengths embraced in the official standards are contrary to the United States cotton standards act. This opinion was made public through the press on June 15, 1928.

EXTRA WHITE STANDARDS PROMULGATED UNDER THE COTTON FUTURES ACT

The standards for extra white cotton, grown chiefly in the arid and semi-arid regions of the Southwest, were first established, effective August 1, 1927, under the United States cotton standards act. On August 30, 1927, the Secretary signed an order, effective September 1, 1928, under which cotton equal to the standards for Extra White will be recognized as tenderable on future contracts under section 5 of the United States cotton futures act.

CLASSIFICATION OF COTTON UNDER THE COTTON FUTURES ACT

The law specifies that all cotton intended for delivery on future contracts shall be classified by officers of the department. The total number of bales classed by the boards of cotton examiners at New York, New Orleans, and Houston-Galveston, Tex., was 137,715 bales, and reviews of 26,943 bales were made by the Appeal Board of Review Examiners in Washington and the boards of cotton examiners in the field.

The provision by the New Orleans Cotton Exchange for optional deliv-

eries on its future contracts in Houston and Galveston, Tex., has increased the work of the Board of Cotton Examiners established to serve these markets, in connection with deliveries on the future contracts of the Chicago Board of Trade.

By reason of the large stock of certificated cotton which was on hand in the port of New York during the greater part of the fiscal year and because of technical conditions in the future markets, the volume of classification work was smaller this year than last.

Collections during the year amounted to \$59,370.79 and disbursements to \$137,035.61. Of the total collections \$6,917.24 was for loose cotton and the balance for classification fees. A balance of \$119,254.90 was in the Treasury on July 1, 1928, for continuing the work during the fiscal year, 1929.

In April and May, 1928, the 172,002 samples representative of the certificated stock in New York, as it stood in March of this year, were examined by a committee of experts employed by the Senate subcommittee investigating the cotton situation. A total of 6,761 of the samples were put aside as doubtful or untenderable under the cotton futures act. Subsequently the Appeal Board of Review Examiners, in company with a committee of expert classers from the cooperative associations and the Boston arbitration committee and the joint southern arbitration board, classified redrawn samples from the 3,316 bales which remained in stock of the 6,761 just referred to. Those found to be actually untenderable numbered 1,425. Of these the classification of 929 bales was not final, this number of bales having been until this time subject to review in the usual manner.

CLASSIFICATION OF COTTON UNDER THE COTTON STANDARDS ACT

Under section 4 of the cotton standards act any person who has custody of or a financial interest in any cotton may submit the same to the department for classification, and the various boards of cotton examiners established under the cotton futures act are authorized to perform this additional service. A total of 15,287 bales were classed under this act.

LICENSING OF COTTON CLASSERS

Forty-five examinations were given to applicants for licenses to class cotton under the cotton standards act,

and 56 licenses were granted, including 31 renewals. Applicants for licenses as classers under the United States warehouse act are required to submit to the same practical test as applicants for licenses under the cotton standards act, and a number of such tests were conducted. The employment of licensed classers by the cooperative associations and the trade generally has done much to encourage the public use of the official standards.

PREPARATION AND DISTRIBUTION OF OFFICIAL COTTON STANDARDS

Practical forms or copies of the official cotton standards are prepared and sold to the public. During the year 4,625 boxes of the standards for grade and color, and 10,762 staple types were distributed, as compared with 6,278 boxes and 5,720 staple types during the fiscal year 1927. The sum of \$31,568.53 was collected from sales of practical forms of the standards. Sales of loose and rejected cotton amounted to 563 bales, for which the sum of \$42,425.90 was received. During the year 568 bales of cotton were purchased for the preparation of practical forms at a cost of \$70,111.27.

Classing schools were conducted in cooperation with the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.; the North Carolina State College of Agriculture and Engineering, Raleigh, N. C.; Clemson Agricultural College, Clemson College, S. C.; and the Texas Agricultural and Mechanical College, College Station, Tex. Demonstrations of the standards in the European markets have been continued. The technical representative of the bureau, through contact with different European trade organizations and individuals, continues to give valuable assistance toward encouraging the successful and satisfactory use of the standards for grade and color in accordance with the universal standards agreements.

FUTURE AND SPOT MARKET INVESTIGATIONS AND COTTON PRICE QUOTATIONS

Closer supervision has been maintained over the quotation of commercial differences in the designated spot cotton markets, and the work was considerably extended, particularly in the collection and dissemination of prevailing premiums for staple cottons as quoted in various cotton-growing and consuming districts. An unusual demand for these data was in evidence from many and varied sources. This

phase of the work is of particular value to growers of such cotton, as it enables them to have a more accurate knowledge of the value of their product. Moreover, the American futures exchanges by amendments to their rules have made cotton of $1\frac{1}{8}$ and 1 inch staple tenderable on future contracts at premiums above cottons of $\frac{7}{8}$ inch.

The particular objects of this project are to insure that tenderable cotton of grades other than Middling deliverable on future contracts made subject to section 5 of the United States cotton futures act shall be settled for at the actual commercial differences in value, and thus to aid in the maintenance of a proper parity between prices of future contracts and spot cotton; and further that producers, merchants, manufacturers, and others interested in spot cotton may be reliably informed as to prices and values of cotton.

The cotton price quotation service has been maintained in five districts, of which Charlotte, N. C., Atlanta, Ga., Memphis, Tenn., New Orleans, La., and Houston, Tex., were headquarters. Reports of purchases and sales of cotton were gathered, and daily and weekly cotton reviews and bulletins were published showing the prices at which the various grades of cotton were sold. In addition to cotton-price data there were included data on prices of cottonseed and cottonseed products. Newspapers and periodicals were glad to publish information assembled, and cooperated with the bureau in this work by publishing daily and weekly reports on the price data which were furnished by Washington and the field offices. Included in the information generally disseminated were quotations giving prices based on active futures months on the future exchanges. This enabled those owning cotton of $\frac{7}{8}$ -inch staple up to $1\frac{1}{4}$ inches readily to ascertain a close approximate value of their holdings.

PREPARATION AND DISTRIBUTION OF STANDARD GRADES FOR AMERICAN COTTON LINTERS

At the request of the industry, the Secretary of Agriculture on October 31, 1927, established and promulgated standards for color for American cotton linters. These standards are descriptive and are based on the normal color of linters, as carried in the samples used in constructing the original standard grades.

In cooperation with mattress manufacturers and with the bureau of bedding of the department of labor and industry of Pennsylvania, samples of

felt have been prepared of linters of the different grades and characters represented in the official standards. These felts are being subjected to various tests to determine the relative value of "character" and "grade" in cotton linters for mattress purposes. The value of the use of standards has been demonstrated by a chain of mills which used the standard grades for linters successfully on all sales of this commodity and in control of manufacture.

To date 1,608 copies of the official standards for cotton linters have been distributed, and 1,871 samples have been classed during the year.

COTTONSEED STUDIES

Additional data have been secured confirming the theory that the net kernel content of cottonseed is a closer and more constant index of the true value of cottonseed for crushing purposes than any other factor. Experimental machines have been designed for the purpose of separating the meats from the hulls and other forms of foreign matter, so as to determine the kernel content, but none of them as yet has proved completely satisfactory.

A study of the values of the two principal products of crushing, oil and cake, brought out the fact that the ratio between the value of a unit of oil and of a unit of protein was practically constant, the variation being less than 5 per cent. The average oil-cake equivalent found in the analyses of 15,000 car lots of seed was 555 pounds. On the basis of this oil-cake equivalent, 555 pounds, as 100 per cent value, a table of percentages of value has been constructed for regular increases and decreases in pounds of oil cake. The method of determining quality through the determination of the free fatty acid content of the extracted oil has proved not only to be highly satisfactory but to have a positive correlation with the manufacturing or refining losses of the oil. A table of discounts has been prepared for each significant increase in the percentage of free fatty acid found to be present. With these two tables the relative value in percentages of the basis quotation of any lot of cottonseed can be found when the chemical determinations have been made.

RESEARCH IN COTTON MARKETING

STUDIES OF THE COTTON MARKETS

Progress was made on two marketing studies during the fiscal year.

The data procured in the study of cotton quotations in the Houston market, begun during the preceding fiscal year, have been organized and presented in graphic form. The charts indicate the extent to which in the season studied variations occurred between the actual price of cotton sold and the quotations of particular qualities. Actual sales prices tended to run above quotations. Prices and quotations were closest together at the peak of the season and farthest apart in the dull season. The Houston market is regarded as one of the two or three most systematically quoted spot markets in this country, and it is believed that the methods in use have been improved since the time the study was made. It is hoped, therefore, that this study may be later continued. The charts indicate the desirability of study of the methods of quoting cotton in other designated spot markets.

During the past year, studies of the relation of local prices to grade and staple length of cotton sold have been made in cooperation with the Texas Agricultural Experiment Station and Georgia Agricultural Experiment Station. A less formal cooperative relation has been carried on also with the South Carolina and the Alabama stations. Work is now in progress to present the results of these studies.

GRADE AND STAPLE ESTIMATES

Grade and staple estimates were made in Georgia and in an area partly in Texas and partly in Oklahoma. Each area produced approximately a million bales of cotton the past year.

Reports were issued in the form of estimates of the grade and staple length and tenderability on futures contracts under the United States cotton futures act of the cotton ginned in the areas referred to.

Plans are well under way to carry out fully during the coming season the provisions of the act of March 3, 1927, which provides for the collection and publication of statistics of the grade and staple length of the carry-over and of the crop as a whole. Offices have been opened at Atlanta, Memphis, Dallas, Austin, and El Paso, and much thought has been devoted to preparing the organization for the work.

UTILIZATION OF COTTON

Work progressed satisfactorily in the study pertaining to the utilization of American cotton by grade and sta-

ple length. In February a report was issued entitled "Domestic Mill Consumption of American Cotton by Grade and Staple," which elicited much favorable comment throughout the United States. Types are being received upon which to base next year's work. In addition, actual samples of cotton consumed in 15 representative establishments using lint from $\frac{7}{8}$ to $1\frac{1}{4}$ inches commercial length are being procured. These samples of cotton actually consumed serve as a general check on the accuracy of the reports of cotton consumed made by individual consuming establishments. In this work excellent cooperation has been had from the spinning industry as a whole through the Cotton-Textile Institute of New York, as well as from spinners individually throughout the spinning districts.

NEW USES FOR COTTON

Studies have been made on new uses for cotton and reports issued on the following subjects: "Cotton Bagging for Cotton"; "Farm Uses for Cotton and Its Products"; "Cotton bags in the Wholesale Grocery Trade." In addition, a supplementary study on "Cotton Bags in the Wholesale Grocery Trade" is being made in cooperation with the American and National Wholesale Grocery Associations.

A study is under way, in cooperation with the National Fertilizer Association, of the amount of fertilizer handled in cotton bags, size of packages, suitability of cotton containers for fertilizers, relative cost of cotton and jute bags for fertilizer, and utility of bags on farms after being used for fertilizer. In cooperation with the Texas Agricultural Experiment Station, a shipping test is being made on cotton bags as containers for wool and mohair, and a study of the relative prices of different bag materials for different purposes is being carried on.

COTTON-FIBER RESEARCH

Cotton-fiber research is a field of much promise. Work of this kind is fundamental, being essential both in economic study and in economic progress in our cotton industry. It is necessary as well to efficient administration of the service and regulatory work of this division. Work has been begun on determining the relationships between fiber quality and the quality of cotton products. A beginning has been made in the development of meas-

ures of quality, first attention being given to uniformity of length.

COLOR TESTING

The Munsell system of color measurement has been adapted to cotton, making it possible to test cotton for color with scientific precision. This method holds promise of great usefulness in the future, in the fundamental work of establishing the relationship between the color of cotton and the color of gray, bleached, dyed, and mercerized yarns and fabrics, and of determining the importance of color as a factor of cotton quality.

SPINNING TESTS

Further technical studies have been made during the year on fiber length and strength as related to yarn strength. Samples of fibers taken from each lot of cotton submitted for tests have been tested for strength by the bulk method developed in this bureau. The results of a series of these fiber tests have been correlated with the spinning results of the cotton thus tested. From these data a formula has been derived by use of which the probable strength of yarn can be estimated in advance of spinning from the data on a small sample of cotton. The results of many of these tests have been published in preliminary reports, and the results of others have been submitted as office information.

During the past year at Clemson College 82 regular lots of cotton, including different grades, staples, and varieties, have been tested, and 39 check tests for special information of the testing force and the division have been conducted. At College Station 52 regular lots of cotton, including different varieties, ginning studies, and harvesting studies have been tested.

DIVISION OF FRUITS AND VEGETABLES

WELLS A. SHERMAN, *in charge*

The division was under the direction of F. G. Robb during the greater part of the year, during which time Wells A. Sherman was chief of the division of markets of the California Department of Agriculture under a cooperative agreement between the State of California and this bureau.

MARKET NEWS SERVICE

Greater publicity than ever was obtained for news regarding crops and

markets, through extension of the series of sectional reviews, issued either weekly or monthly. These reviews, adapted to a particular region or section, are widely published in newspapers and farm journals and have a large circulation. The series of special commodity summaries or reports, issued at the opening of the season for important products, was also extended and has met with great favor.

New temporary offices in producing sections were added for winter lettuce in Arizona, miscellaneous vegetables in the Belle Glade-Chosen district of Florida, and onions at Farmersville, Tex. Local and State agencies cooperated to a greater extent the past year in conducting the work at temporary field stations. The total shipments of 38 fruits and vegetables as reported during the year increased only slightly to 1,044,000 cars, mainly because of the reduced production of tree fruits.

The outstanding cooperative project was the clearing house for California grapes. One member of the technical staff was furloughed to assist with this work, and another man was employed on a cooperative basis during the grape-shipping season. Comprehensive arrangements with the railroads made it possible to obtain the reports desired by the clearing house, and all market-news representatives in important cities cooperated in this work. The clearing-house operations were expanded during the 1928 season to include deciduous-tree fruits. This general plan of aiding in the orderly marketing of heavy crops of fruits and vegetables—the clearing-house plan—appears to be meeting with greater favor each year.

The bureau's 7,500 miles of leased telegraph wires continued to be a means of rapid dissemination of market news, including shipment reports, arrival and price information, and statements regarding local conditions in producing sections and terminal markets.

TRANSPORTATION LINES FURNISH CAR-LOAD-SHIPMENT INFORMATION

The total of 1,043,946 cars of 38 products represents a net increase of about 1,750 cars over the number in 1926. The gain would doubtless have been greater had there not been a generally short crop of tree fruits in 1927.

Daily telegraphic reports are received at Washington from several hundred transportation lines, showing the number of cars originating in each division

superintendent's territory. About 68 of these reports are known as "consolidated wires," each covering an important railroad system or major portion of such a system. Approximately 400 individual division superintendents or other reporting officials send daily wires in season, making a total reporting daily of 468. About 15,000 local freight and express agents send monthly (station) reports by mail, covering a greater number of products than those in the daily wires.

In cooperation with the clearing house for California grapes in 1927, grape shipments were segregated as between white and black varieties and juice and table stock. At certain important gateways daily passings were obtained from each railroad concerned. At all city market stations, daily arrivals of grapes, the number of cars on track, and the daily unloads were secured. On Friday of each week a detailed list of cars held for disposition was furnished the clearing house. For the season of 1928 more information will be obtained from railroads. In addition to the regular market stations a number of other important cities have been included, from which daily information is received. A large number of tree fruits have been included, along with grapes, in the clearing-house program for 1928.

During 1927, the market news service conducted 38 temporary field stations, and a number of market stations served near-by producing areas. In most instances, the carriers furnished such offices with daily wires on certain commodities, including destinations of shipments. Some of the offices received passing-point information.

MARKET REPORTS ON PEANUTS

Weekly reports were issued from Washington which contained all information gathered from various sources. Quotations covering prices paid for farmers' grade stock and selling prices for shelled and unshelled peanuts, peanut oil, and peanut meal and cake have been furnished by branch offices. Supplementary information on prevailing prices in the producing areas has been obtained from peanut brokers in the large consuming centers. Weekly telegrams from a number of the branch offices furnish reports on car-lot arrivals and boat receipts during the past week, market conditions, and selling prices or quotations on large lots of both cleaned and shelled peanuts.

Records of peanut shipments have been obtained through the agents of the different railroads and boat lines serving the Virginia-North Carolina, the southeastern and the southwestern producing areas. The bureau representatives on the Pacific coast furnish information as to market conditions and prices of Chinese peanuts, f. o. b. Pacific coast points, and the importations of peanuts and peanut oil. Information is also obtained on imports from the Department of Commerce.

MARKET REPORTS OF HONEY AND BEESWAX

About 110 important beekeepers and honey shippers report market prices, conditions affecting colonies and nectar-producing plants, etc., which are combined for publication in the honey market news reports issued from Washington. Bureau representatives also wire semimonthly reports of the market conditions and of the prices of extracted and comb honey in their respective cities. Reports from several markets cover beeswax also. Statistics of the imports and exports of these commodities have been obtained from the Bureau of Foreign and Domestic Commerce and published in the market reports.

UNLOAD REPORTS FROM PRINCIPAL MARKETS

Reports of unloads of important fruits and vegetables are received from 66 cities. Representatives of the bureau in 25 markets and railroad agents in 41 other markets furnish reports of the number of cars of each of the 19 principal fruits and vegetables unloaded. Reports are received also from boat lines. Unload information has been prepared in condensed form to supply the increasing demand for such data. The figures are used in summaries of the business of a season in specified producing sections and in other reviews. The data are of great value because they show the monthly and annual receipts of various products in large consuming centers, as well as the sources of supply. Press releases or mimeographed statements are prepared for public distribution on the basis of these figures.

REVIEWS, SUMMARIES, AND SPECIAL REPORTS

The Washington office maintains current tabulations of market prices and

records of conditions prevailing at all the leading markets and shipping points, prepares special reviews and summaries based largely on these statistics, and writes articles for trade papers and farm journals.

The Weekly Market Review of Fruits and Vegetables analyzes and compares the market movement and prices of the week. The review is circulated from Washington and is also sent by leased wire each Tuesday to the branch offices for duplication and circulation. Wider distribution is effected through newspapers and other journals on the mailing lists at the respective offices.

Each Tuesday the Weekly Summary of Car-lot Shipments is mimeographed and distributed. This publication is statistical in nature and summarizes in comparative columns the car-lot shipments of the principal fruits and vegetables as reported telegraphically by the carriers each day. It affords a valuable comparison of the past week's shipments with those of the preceding week and with the corresponding period of the year before.

A monthly market review, issued about the 15th of the month to 15 farm papers and 6 newspapers, tells of the market trends during the preceding four weeks. One review is prepared on the 1st of each month for the special benefit of six papers that go to press early, and another on the 10th of the month.

Short weekly reviews adapted to various sections of the country are issued to about 20 farm journals and 35 newspapers or press associations. These get a wide circulation and are very popular.

Combination reviews are prepared for a large number of papers which summarize the market conditions for cotton, grain, hay, livestock, meats, poultry products, butter, cheese, wool, etc., along with a summary of the fruit and vegetable situation. The circulation of these reports is very extensive among the farming population in all parts of the country. A special weekly report also is prepared for radio broadcasting.

The monthly issues of Crops and Markets contain several pages of statistical material showing car-lot shipments by States and by products, and monthly range of jobbing prices on the principal fruits and vegetables.

The series of special commodity reports has been continued and has met with great favor. Several pages of

text discuss the crop and market prospects for the coming season and analyze the statistical matter published with the report. Tabulations relate to acreage, production, shipments, unloads, prices, etc., so as to bring together all the available material affecting the market position of the particular product at the height of the season.

Work is done through the Associated Press and other news agencies. Some field stations also have been able to use this extensive publicity service.

After the close of each temporary field station the local representative writes a summary of the daily information that was published during the period of operation, together with a general review of the marketing season in that territory. This summary is distributed to all persons who request a copy and to the press. This summary in the hands of farmers points out the successes and failures of the past season, and serves as a guide in the planting, harvesting, and marketing of the crops the following season.

Early each year mimeographed tabulations are issued showing the total monthly car-lot shipments of each of 38 fruits and vegetables, on the basis of originating States. These annual shipment reports or summaries for each product are in great demand. Thousands of copies are distributed, as they furnish one of the best and simplest means of determining the general shipping season for a particular fruit or vegetable in any State.

COOPERATIVE WORK INCREASES

Cooperative market news work was continued in 20 States. In 6 of these States the fruit and vegetable work has been incidental to a general market news program, but in the other 14 States specific fruit and vegetable work has been provided for. All except three of the temporary field stations for market news work are financed by the aid of State or trade agencies and could not be operated without their contributions. Special cooperative services are conducted on particular crops, such as grapes in the Chautauqua-Erie grape belt.

This bureau furnished information and assisted in the conduct of the clearing house for northwestern prunes both in the Walla Walla district and at Boise, Idaho. Reports of f. o. b. prices and reports of car-lot movement, arrivals, etc., were furnished all members of the clearing house. A clearing house on grapes was operated by

the California Vineyardists Association and information was furnished by this bureau. The clearing-house plan has been extended this year to include a large number of tree fruits in addition to grapes.

During 1927 it was possible through local cooperation to open three new temporary offices, one for spring lettuce at Phoenix, Ariz.; one for winter lettuce at Phoenix, and one for vegetable crops at Belle Glade-Chosen, Fla. In the spring of 1928 a field station for Bermuda onions was opened for the first time at Farmersville, Tex. Largely because of the lack of local interest and local financial aid, the potato field station at Charleston, S. C., was not operated in 1927 or 1928, and the strawberry field station was not opened at Judsonia, Ark., in 1928.

A preliminary study has been made of truck receipts in New York and other large markets, as it is felt that arrivals by truck are becoming increasingly important and are having more and more effect on marketing conditions and prices. State marketing agencies in New York and New Jersey cooperated in this new project. Prices are being studied in relation to market supplies.

INSPECTION SERVICE ON FRUITS AND VEGETABLES

Both receiving and shipping point work has been conducted on the same basis as during the three previous years. While shipping-point inspections showed an increase of 17,290 cars, there was a decrease of 364 cars in receiving-point inspections.

RECEIVING-POINT INSPECTIONS

Branch offices were maintained at 40 important receiving markets, and inspections were made also at adjacent points from which requests were received. Altogether 32,430 commercial inspections were made, and in addition large quantities of products were inspected for the United States Navy and other Federal agencies, as well as for a number of steamship companies. Only 19 reinspections were requested, and in 10 of these the original report was sustained. Especial attention was given to inspections for arsenic-spray residue on export shipments. Chemical analyses were made of samples of fruit, and the export form certificate was not granted if the amount of arsenic exceeded 0.01 grain per pound of fruit. Satisfactory progress has been made in the adoption by

fruit growers of methods of washing fruit to remove the spray residue.

AMENDMENT TO RULES

In February, 1928, the rules were amended so as to make it possible to take care of some additional work in some of the larger markets which could be handled without additional expense. This amendment provided that any applicant who shall have paid for 500 or more car-lot inspections in any one market within the period of one year immediately following the filing of a declaration of his intention to avail himself of this privilege shall receive a refund from the department at the rate of \$1.50 per carload for the first 500 cars, after which the fee for such applicant shall be \$2.50 per carload for the remainder of the year. A total of 15 firms signed the declaration of intention to avail themselves of this privilege, and it is believed that it will result in a large increase in the number of inspections in some of the markets.

AUCTION INSPECTIONS

The inspection of juice grapes sold at auction in Chicago continued. The agreement entered into with the United States Fruit Auction Co. was renewed, and a total of 830 cars was inspected. Both the buyers and the auction company expressed their approval of the service rendered by the Federal inspectors, who exercised great care in selecting samples that fairly represented the quality and condition of the cars from which the samples were taken. The written reports issued by the inspectors were of great value to the buyers, but the success of this new line of work can be attributed largely to the fact that the buyers had confidence in the integrity and neutrality of the Federal inspectors.

SHIPPING-POINT INSPECTIONS INCREASE

A total of 210,832 cars were inspected at shipping points, which represents a net increase over last year of 17,290 cars. California showed the greatest increase of any State which amounted to approximately 10,000 cars. Practically all shipping-point inspections are made under cooperative agreements. The service was maintained in 41 States, and covered approximately 60 commodities. Of the 210,832 cars inspected at shipping points, there were 264 reinspections made at receiving markets, of which 90

sustained the original inspection and 174 reversed it.

RESEARCH AND STANDARDIZATION

The use of national standards has increased from year to year, and at the present time the bureau has recommended standards for 38 fruits and vegetables. With some commodities such as grapes the trade requires separate standards for different types, so that 49 United States standards have been issued. The inspection of 243,262 cars of fruits and vegetables during the past year were made largely on the basis of the United States standards. Although accurate information is not available, it is estimated that approximately 60 per cent of the wholesale trading in fruits and vegetables is done on the basis of national standards.

Constant research is necessary to revise and improve the United States standards, so that they will conform to good commercial practice and be satisfactory to the trade. During the past fiscal year standards were promulgated for garlic and apricots. Apple export standards as applied to condition factors were also issued. Revisions were made in the standards for a number of other products. Standards have been issued for raw tomatoes delivered to canneries, and investigations made with a view to establishing grades for other cannery products. Practical studies have been made and reports prepared on the handling and marketing of potatoes, strawberries, and eastern grapes. Studies have been made also of the origin and distribution of important fruits and vegetables.

During the 1927 shipping season through the cooperation of the California Vineyardists Association the bureau obtained and assembled certain information not previously available regarding the marketing of California grapes. This information including daily interstate shipments by variety, points at which they were unloaded, and their primary destinations with daily unloads by classes in 29 markets and other similar data has been assembled in bulletin form for distribution to those interested in marketing grapes.

The bureau is conducting a general study of the apple industry in cooperation with many State agencies. A mimeographed report has been published giving the relative importance of commercial varieties and sources of carload supply on 41 important mar-

kets. A manuscript for a bulletin discussing the market supplies and prices of apples is about completed.

The bureau's foreign marketing specialist in London has continued rendering service to producers and exporters concerning the condition of United States fruits arriving in Europe and its relation to grading, packing, and shipping methods. A London circular was again issued biweekly and forwarded to European agents who distribute United States fruits, giving information and grades, inspection, movement, and prices in the United States. During the summer months the specialist has returned to the United States, where he has visited growers and shippers in producing districts and addressed meetings to discuss the foreign marketing problems.

STANDARD CONTAINER ACT

The work on standard containers was increased by the passage of the standard hamper and basket act on May 21, 1928. The new act provides specifications for hampers, round-stave baskets, and splint baskets. The passage of this act completes the scheme of standardization of wooden containers for fruits and vegetables with the exception of crates and boxes.

Both the standard container act and the standard hamper and basket act are administered largely through educational work with the manufacturers. Manufacturers submit samples and specifications of their products to the bureau for approval before they turn out their product. The work of testing sample containers has been extremely heavy. Of the 4,421 containers tested, 907 or 20 per cent were found to be nonstandard. Excellent cooperation has been received from the manufacturers in administering the provisions of these laws.

COLLECTION AND DISTRIBUTION OF 1918 EXCESS WOOL PROFITS

In view of the pendency of an excess wool profits case (*U. S. v. W. A. & J. Norris McFarland*) in the Supreme Court of the United States, action on other cases pending in Federal district courts was not urged. The McFarland case was argued before the Supreme Court on October 7 and 10, 1927. However, the Supreme Court, on October 17, 1927, revoked the writ of certiorari, thereby dismissing the case, on the ground that "the decision of this case does not require a decision

of the questions which are presented in the petition for certiorari because of which the writ was granted." This action failed to decide any of the legal questions relating to this work. Consequently, Congress granted a deficiency appropriation of \$2,500 in December for the prosecution of cases during the remainder of the fiscal year. It was not possible, however, to bring any pending case to trial, although one case was argued before the Federal court in Chicago on April 9, a brief was filed in one other case, and steps were taken toward expediting the trial of several cases in the coming fall.

PRODUCE AGENCY ACT

The produce agency act became effective July 1, 1927, but funds for its enforcement were not available until approximately January 1, 1928. Copies of Service and Regulatory Announcements No. 107, containing the law and the regulations, were given a wide distribution throughout the country. Health officers were advised as to their designation as one of the classes authorized to make produce agency act inspections, and were furnished with samples of applications for inspection and certificates.

During the fiscal year 92 complaints were filed under the act. Of these 12 were found to be joint accounts, or purchase and sales transactions not coming under the act and had to be dismissed. Of the 80 cases which did appear to come under the act, 62 had been closed at the end of the fiscal year, and 18 were still pending.

Of the 62 cases which have been closed 33 were made the subject of personal investigation, the rest being handled by correspondence. In 10 cases settlements were effected as a result of the activities of this office, the settlements involving either the entire amount due or balance due. Three cases have been sent to the office of the solicitor. One of these is in the hands of the United States district attorney at Los Angeles and it is understood will come up for trial some time during the next six months.

LIVESTOCK, MEATS, AND WOOL DIVISION

C. V. WHALIN, *in charge*

Progress was made in the three fields of activity—research, service, and educational demonstrations.

The service activities embraced a nation-wide market news service which

made available to the public reliable and up-to-the-minute information on supplies, demand, and prices in the leading livestock, meat, and wool markets of the country and a meat-grading and meat-stamping service which makes it possible for meat purchasers of both large and small scale to buy standard-grade meats and meat products.

The research activities were centered largely on grade standardization, marketing methods and practices, and projects involving studies of supply, distribution, demand, and price as related to livestock and meats.

GRADE STANDARDIZATION

The grade-standardization program was carried on along the lines laid down in earlier years, the procedure being that of making investigations, formulating standards, and demonstrating their practicability and usefulness in the market place and on the farm and range. The division's work in this field of standardization has aroused nation-wide interest and has been one of the principal factors in making it possible to develop the present market news service.

LIVESTOCK AND MEATS

The investigational work in livestock and meat-grade standardization is conducted in close cooperation with the market news service and with the active assistance of the entire staff of that unit. The market news service in turn is dependent on the completed standards for the proper conduct of its work.

Much work was done in the way of revising, refining, and clarifying tentative standards already developed. Special attention was given to thus treating the grade standards for 5 classes of slaughter cattle and for 6 grades of vealers, 6 grades of slaughter calves, 6 grades of veal carcasses, and 6 grades of calf carcasses. Specifications for these standards were revised in keeping with criticisms and suggestions and they are now ready for formal promulgation as official United States standards. Work was done in revising the tentative standards for yearling beef. Work on standards for slaughter hogs and for slaughter sheep and lambs was conducted throughout the year. A large number of carcasses have already been measured and considerable data assembled for study.

Publications dealing with standardization matters constitute one of the important means of education used. A circular entitled "Market Classes and Grades of Calves and Vealers" was printed, and manuscripts entitled "Advantages of Grade Standards for Livestock and Meats" and "Market Classes and Grades of Dressed Veal and Calf Carcasses" were prepared. Work has continued on market classes and grades of hogs.

A series of colored posters illustrating class and grade standards has been begun. Photographs illustrating seven grades of slaughter steers have been selected and hand-colored for lithographing. A similar poster illustrating grades of slaughter cows is in preparation.

An outstanding feature of the extension program was a series of approximately 90 grading demonstrations conducted in 10 States. At most of the meetings the specialist in charge had considerable numbers of live animals and illustrated the standards by actually grading the animals before his audience, in all instances giving careful explanations. Numerous addresses were made at meetings of agricultural workers, vocational teachers, and others.

QUALITY OF MEAT STUDY

The study of the factors which make quality and palatability carried on in cooperation with the Bureau of Animal Industry and 16 State agricultural experiment stations was continued, and another 1,000 cattle and their carcasses were studied. They were graded first as feeders, later as slaughter cattle, and after slaughter the carcasses were graded. These cattle were fed by the State and Federal experiment stations, thus making it possible to work with cattle of known history. The cattle used included heifers and steers of different grades ranging in age from calves to 4 year olds. All ages and both sexes were graded according to the divisions' tentative standards. Besides the cattle approximately 400 slaughter lambs and their carcasses were graded. In addition to the grading of live animals and their carcasses various kinds and cuts of meat were physically and chemically analyzed and were then cooked and graded for color, flavor, tenderness, juiciness, and general palatability.

The results from grading 627 cattle, among them being purebreds, crossbreds, scrubs, and Brahmas, show

that the grading committee placed 97 per cent of the carcasses within the same grade as the one to which they had assigned the live animals from which the carcasses were obtained. This indicates that it is possible to grade live animals successfully and that the grade of the animal is indicative of the meat it will yield.

WOOL

A keener realization of the benefits of standards for wool grades is indicated by the increasing requests from wool-growers' associations, agricultural colleges and universities, and the State and extension workers for information concerning the division's standards. During the year 175 partial and 77 complete sets of the wool standards and 16 complete sets of the official wool-top standards were prepared. Many of the sets have been lent to universities, educational institutions, and county agents for use in educational work in the schools and in the field. Six sets of the official wool standards were sent to the Central Chamber of Commerce, Valparaíso, Chile, and a request for two sets has recently been received from Poland. Sets of the proposed international wool standards comprising 12 grades, based on the numerical system of nomenclature, have been sent to all parts of the world for exhibition purposes. An exhibit of wool and wool-top grades also is being prepared to be sent to Spain. The standardization of wool and top grades has provided a basis for working out improved methods of marketing wool and wool-top products.

MOHAIR

The demand for mohair standards continues, and it is anticipated that standards will be ready for promulgation during the coming year. A manuscript for a bulletin on the Angora goat and mohair industry has been prepared in cooperation with the Bureau of Animal Industry, the Forest Service, the Bureau of Standards, and the Bureau of Foreign and Domestic Commerce.

WOOL-SHRINKAGE RESEARCH

Investigations relative to the shrinkage of wool of different grades were continued, and a large number of test samples were scoured, and reports showing the grade and shrinkage of the samples were sent to those who

furnished them. In addition the division sorted, graded, and scoured 187 fleeces of wool received from the Utah Agricultural College and furnished the college with a report showing the percentages of each grade in the several fleeces and the shrinkage of each fleece. The results from these tests are expected to be of interest to wool growers and will be helpful in establishing a basis for estimating shrinkage of wools produced in different sections.

Further study as to the possible damaging effects on wool of pine-tar oil, which is used as a fly repellent in some sections, was conducted during the year. Two samples of wool in the grease (one fine and one medium) were treated with commercial pine-tar oil, and two like samples were treated with a refined pine-tar oil. These samples were allowed to remain under natural atmospheric conditions for a period of 90 days, after which the samples were scoured. It was found that considerable tar residue adhered to the wool in both samples and that the fibers in each case were badly discolored by the oil treatment.

HIDES AND SKINS

Surveys of existing conditions in the hide and skin industry with a view to developing standardized grades for hides and skins were continued. Several conferences have been held with leading representatives of the industries which use hides and skins and a tentative grade classification has been prepared and is being subjected to various tests to determine its practicability.

METHODS AND PRACTICES OF MARKETING

Research in this field was confined almost wholly to a study of direct buying of livestock, particularly hogs, by packers. There is much interest in this subject in view of the rapid changes taking place in marketing methods, and the bureau has the most complete information available as to the extent that different methods are being used. This information covering a period of five years has been summarized so as to show the number of hogs bought annually at public markets and direct by more than 300 individual slaughtering plants. The summary when ready for publication will show the growth of direct buying and the sections where it is practiced most extensively.

Among the important factors contributing to the changes taking place in livestock-marketing methods are the building of improved highways and the increasing use of motor trucks for transporting livestock. In order to visualize the importance of the new methods of transportation in connection with livestock marketing the division has collected and summarized for publication statistics showing the growth of the "drive-in" business at public markets. These statistics show that a very large proportion of the livestock marketed annually is being transported in motor trucks and that this proportion is rapidly increasing.

SUPPLY, DISTRIBUTION, DEMAND, AND PRICE STUDIES

The analysis and interpretation of the economic information assembled by the market-reporting staff has developed into one of the most important research activities. The results of these studies serve as the basis for the semiannual livestock outlook reports and for reviews and special reports dealing with the livestock and meat situation released at various intervals throughout the year.

Four studies in this field were inaugurated, as follows: (1) A study of the factors affecting beef-cattle prices; (2) a study of the factors affecting the seasonal and yearly supply of hogs for commercial slaughter; (3) a study of the relation of wholesale and retail prices of pork and lard and hog prices; and (4) an analytical and interpretative study of economic conditions in the livestock industry during 1927. The results of the last study were summarized for publication as the fourth annual livestock review issued by the bureau and was published as Miscellaneous Publication No. 28.

STATISTICAL SECTION

Much of the basic statistical material used in the research work of the division is obtained in connection with the operation of the market news service. Compilations and tabulations for permanent records include the following: Daily livestock prices by 60 classes and grades at 22 markets; daily fresh-meat prices by 43 classes and grades at 4 markets; daily cured-meat prices by 10 classes and grades at 4 markets; weekly wool prices at Boston; computation of weekly, monthly, and yearly averages of the above, and typing and mimeographing them for permanent record and for distribution; actual daily receipts of cattle, calves, hogs, sheep, and

horses and mules at 18 markets; monthly gradings of meat by class for steamship companies and other Government and commercial concerns at 17 markets; and the gradings of Good, Choice, and Prime beef at 10 markets.

Compilations and tabulations for current publication include comprehensive data on receipts, slaughter, shipments, and prices of the various kinds of livestock, with comparisons and averages. In addition, a large volume of statistical work is regularly carried on in connection with the market-reporting service at the leading market centers—Chicago, Kansas City, Omaha, and St. Paul—where records are compiled showing the distribution of market receipts and stocker and feeder shipments of cattle and sheep by class, grade, weight, and State origin and destination.

PUREBRED LIVESTOCK PRICE SURVEY

The fourth annual purebred livestock sale price survey covering sales in 1927 was made, and the results were summarized in 18 separate reports. These reports were based on the selling prices of 30,490 beef cattle, 22,838 dairy cattle, 35,437 hogs, and 16,557 sheep, making a total of 105,322 purebred animals. The reports show that the trend of prices of purebred animals continues upward and that a stronger demand existed for breeding stock in 1927 than in 1926. Information of this kind based on actual reports of breeders and published annually tends to stabilize prices and keeps buyers and sellers informed as to prevailing values.

WOOL STATISTICS

The regular quarterly survey of wool stocks in the hands of dealers was continued throughout the year and was released jointly with the information collected by the United States Department of Commerce on stocks held by manufacturers.

The compilation of international wool statistics was given attention, and increasing interest is being manifested among the various organizations of wool dealers. A representative of the bureau made a trip to Europe to attend a conference of the international wool committee, which is endeavoring to work out plans for such statistics.

MARKET NEWS SERVICE

During the year 30 of the markets and wholesale meat-distributing cen-

ters of the country were served from branch offices located in Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Fort Worth, Indianapolis, Kansas City, Lancaster, Los Angeles, National Stock Yards, Ill., New York City, Ogden, Omaha, Pittsburgh, Philadelphia, Portland, Oreg., St. Joseph, St. Paul, Salt Lake City, San Francisco, and Wichita.

The livestock markets reported included those located in all the above cities (Philadelphia excluded) and the market at Jersey City, which is covered by the New York office. A supervised reporting service of limited character was conducted at Sioux City and Baltimore. Wholesale meat-market conditions and prices were reported at Boston, Chicago, Philadelphia, and New York City. Wool-market reports covered the Boston market.

Daily and with few exceptions, weekly telegraphic reports of the 30 markets were released and given dissemination by leased and commercial telegraph wires, the leading press associations, private-wire houses, ticker services, etc. Many regular and special reports also were prepared for metropolitan and country newspapers, the market press, agricultural and trade journals, financial institutions, and others. Radio-broadcasting stations were served by every office, and an extensive bulletin-board service was maintained at all the livestock markets reported. Daily and weekly mail reports were released from most offices.

Expansion and refinement of its radio market news service probably represent the outstanding accomplishment in increasing the dissemination of market information. This was done with little or no additional expense, as the broadcast stations gladly gave the fullest cooperation. A statement covering radio service is shown later under the Division of Information.

The dissemination of market news through the columns of metropolitan and country newspapers, the market press, and agricultural and trade journals was continued. All of the leading news-press associations extended their use of the market-news reports, and several hundred country newspapers took advantage of the weekly mail reports and in some instances requested telegraphic reports to be filed at their expense. Metropolitan papers with large circulation in rural districts and trade and agricultural papers devoted more space to the bureau reports.

The C. N. D. (commercial news dispatch) service conducted by the Western Union and the Postal Telegraph Companies continued to use the livestock reports in supplying patrons with livestock information. The C. N. D. reports are filed for telegraphic transmission at regular periods during market hours, the number of reports filed depending largely upon the size of the market and the requests for the service.

Although the market news has become available through the increased number of radio stations and through the press, only slight reduction has been possible in the number of individuals receiving its mimeographed reports. Approximately 4,745,000 copies of regular mimeographed reports were mailed to subscribers from all of the field offices.

ADVANCE AND MORNING ESTIMATES

Trade interests watch closely and attach great value to the advance and morning estimates of livestock receipts that are compiled as a part of the market-news service as it is conducted at the major livestock markets. This work requires the hearty co-operation of the railroads, since reports made by the carriers form the basic information for the reports.

The morning estimates of receipts for the current day are released at most markets about 6 a. m. Advance estimates for the following day are in most instances released from 11 a. m. to 12 o'clock noon and are based on railroad reports of livestock in transit and car orders. Since the advent of the radio the advance estimates have taken on added significance as a factor of much importance in effecting more orderly marketing, for prospective shippers now not only have the preceding day's market conditions to assist them in determining their immediate action, but those within a radius of some 200 miles of the market center have knowledge of the estimated supply on the market for the current day in addition to the early Government reports of the current day's market trend and the advance estimates of receipts for the following day to guide them in deciding whether to market or withhold their shipments.

MEAT GRADING AND STAMPING SERVICE

The division's meat-grading service was materially expanded during the year to meet the increasing demands

for the service, and almost 23,000,000 pounds of meat were graded and accepted for those using the service. This service is now available in 15 cities. While there has been an increasing demand for the service at all points, the greatest increases were made at New York and Chicago. A large part of this work is performed for other Government agencies. Other users are railroads and steamship lines, hotels, and hospitals. Approximately 8,325,000 pounds of meat were graded and accepted for the Shipping Board alone.

The beef grading and stamping experiment inaugurated May 2, 1927, was continued with very satisfactory results, and a total of 60,707 carcasses aggregating more than 33,000,000 pounds of beef was graded and stamped during the year. This was in addition to the meat graded as a part of the regular grading service, to which reference was made above. The experiment demonstrated the feasibility and practicability of a uniform system of grading fresh meats and that grade identification could be established by a relatively simple method of stamping. The practicability of the service having been demonstrated, it was decided to continue it after July 1, 1928, on a fee basis, or as an essential part of the meat-grading service, and practically all slaughterers at centers where graders are stationed have indicated a willingness to pay for the service.

OPERATION OF CENTER MARKET

C. H. WALLEIGH, *superintendent*

The policy prevailing in previous years regarding the management and control of Center Market was continued. Owing to the fact that legislation is pending for the discontinuance of the market, only such repairs and alterations were made as were necessary to maintain satisfactory service. Financial reports were required from all stand holders within the market. These reports show gross sales, volume of business handled, and expenses incurred in its conduct.

GRAIN DIVISION

H. J. BESLEY, *in charge*

The work of the grain division is divided into two parts: (1) Regulatory, enforcement of the United States grain standards act; and (2) standardization and marketing studies.

The enforcement of the grain standards act is directed from the Washington office and through general field headquarters at Chicago, including the board of review and the force in charge of inspection efficiency. Under direction of the general headquarters, Pacific coast headquarters are maintained at Portland, Oreg. There are four division supervisors and 34 district offices.

At the close of the year there were 132 regular inspection points and 24 additional points which were covered, and 459 licensed inspectors.

CONTINUED GROWTH IN WORK UNDER GRAIN STANDARDS ACT

The steady increase in the reliance which the grain trade has placed on the application of the standards by the Federal supervisors has thrown a heavy burden upon the field offices. In addition to the increased requests for appeal certificates, numerous problems have arisen which made intensive supervision of the grading work imperative. Adverse weather conditions during harvest time and the increased use of the combine resulted in large quantities of damp wheat going into storage, which was followed by much "out-of-condition" wheat in the markets. Complaints involving several hundred thousand bushels of wheat were referred to the Secretary of Agriculture. Samples of the grain involved were submitted to groups of experts in five of the leading grain markets who, without exception, vindicated the position taken by the board of review.

Questions of musty, sour, sprouted, and heat-damaged wheat were involved at many points. An unusual amount of garlic was present at some points. Frost damage was severe in parts of the hard-red spring and durum districts. A great deal of personal attention was given by offices of the bureau to securing satisfactory grading of the grain in question and in bringing about a correct understanding of the factors involved.

The records for the year show a marked improvement in intermarket uniformity of grain inspections throughout the country. Both the percentage of shipments grading the same and grading the same or better, in both markets, showed improvement for all grains. The primary purpose of the passage of the United States grain standards act was to bring about uniformity in grain inspections throughout the country. The increase in in-

termarket uniformity of inspections since the act was passed has been very substantial.

CONTINUED INCREASE IN GRAIN APPEALS

Approximately 160,000,000 bushels of grain was graded and certificated by the department during the fiscal year 1928, as a result of appeals filed through the several offices of Federal grain supervision, appealing from the grades assigned by inspectors licensed under the United States grain standards act. A total of 80,618 lots was appealed, an increase of 32.4 per cent over the preceding year, and nearly 100 per cent more than was appealed during the fiscal year 1926.

The Duluth office led the offices in the total number of appeals handled, with 18,488. Chicago was next, with 14,436; Kansas City was third, with 13,552. A board appeal or superappeal was filed in 1,355 cases by parties dissatisfied with the district supervisor's grade. The fees and charges collected for the inspections amounted to \$97,356.79, which went to miscellaneous receipts.

MILLING AND BAKING STUDIES

The wet weather prevailing in the Southwest immediately after the harvest of the 1927 crop of wheat resulted in much of the shocked and stacked wheat having a questionable odor. In order to assist in the proper interpretation of the Federal standards (grades) with respect to this factor, a number of milling and baking tests were made on samples of wheat carrying questionable odors. In addition, milling and baking tests were made on samples of wheat for the Bureau of Plant Industry in connection with the development of new varieties having superior milling and baking qualities and for the Bureau of Chemistry and Soils in connection with their study of the effect on yield and quality of wheat of applications of sodium nitrate to the wheat plant in various quantities and at different stages of growth.

The study of world wheats, begun the previous year, was completed, and considerable progress was made in the preparation of the results for publication as a technical bulletin. This study involved milling, baking, and chemical tests on 900 commercial and varietal samples of wheats obtained from 38 different countries. The information resulting from this study should be of considerable value in con-

nection with the determination of the effect of world crop conditions upon the market value of our own wheats and as a basis for the most advantageous marketing of our surplus stocks of wheat.

The results of a study of the relationships existing between kernel texture, protein content, and test weight per bushel of hard red spring wheat, were published as an article in the *Journal of Agricultural Research* under the title "Correlation of Kernel Texture, Test Weight per Bushel, and Protein Content of Hard Red Spring Wheat." A similar study was made on hard red winter wheats, and considerable progress has been made in writing up the results for publication in the *Journal of Agricultural Research*.

Cooperation was extended to the Delaware, Indiana, and Kansas Agricultural Experiment Stations in the study of the milling and baking characteristics of certain wheat varieties.

CHEMICAL STUDIES OF GRAIN

A chemical study was made of the nature and kind of oil found in the garlic bulblets commonly found in soft red winter wheat. Special attention was paid to the question whether this oil retained its potency from the time of harvest until the bulblets became dry the following spring. The influence of garlic bulblets at different moisture contents upon the milling quality of wheat was studied. It was found that over long periods of time the oil remained pungent within the bulblets, only awaiting the presence of moisture to make them again as active as when freshly harvested. The results of the tests are of importance in connection with the proper interpretation of "garlicky wheat" in grading grain under the provisions of the grain standards act.

A comprehensive laboratory study was made of the quality and quantity of the gluten in wheats grown throughout the world in order to compare them with those grown in the United States.

Extensive research work was devoted to the out-of-condition wheat referred to in the grain trade as "sick" wheat. Laboratory studies of various sorts were made on this type of out-of-condition grain, and it was found that the only chemical constituent of the kernel of wheat which becomes altered in a pronounced manner so that it could be said that the kernel had been subjected to abnormal conditions was the fat in the kernel. This constituent be-

comes altered with the liberation of a large amount of free fatty acids. The amount of acids formed is in direct proportion to the amount of fermentation which the wheat has gone through. Studies were made comparing the development of acidity in the kernel with the milling and baking qualities of large numbers of "sick" wheat samples.

In cooperation with the Bureau of Plant Industry several hundred flax samples were analyzed for their oil content as an aid to the breeding of flaxseed varieties, and durum wheat samples for their carotin content.

DOCKAGE AND GRAIN CLEANING

The results of a survey of the dockage in wheat and flax delivered to country elevators in the four spring-wheat States show that dockage, so far as the farmers are concerned, has not decreased, but that the dockage in the grain received in the terminal markets from the spring-wheat area has decreased somewhat because of the increase in the practice of cleaning grain on the farm and at the country elevator. Demonstrations were made of new methods for cleaning grain, and considerable publicity was given to the advantage of cleaning grain on the farm. In the California rice belt many rice farmers installed on their threshing machines the grain-cleaning device known as the Bates aspirator, which was developed in the bureau. The rice that was cleaned with this device commanded a premium on the market and was also in better condition for seed purposes. A combination grain cleaner and copper-carbonate dust treater for seed grain was developed and assistance was rendered a group of farmers in California in the construction of the machine. The results of the operation of this machine were entirely satisfactory and stimulated other groups of farmers to install similar machines. In cooperation with a grain-cleaner manufacturer a grain cleaner was designed for attachment to a combine, and this machine will be tried out during the 1928 harvest season in the spring-wheat area.

RICE STANDARDS RECOMMENDED

During the past year United States grades for brown rice were prepared and recommended to the trade. A handbook was prepared in which the grades for rough rice, brown rice, and milled rice were incorporated. The

handbook contains also a description of proper methods for applying the grades, including a description of the apparatus needed for grading rice and the proper methods of use. Contact has been maintained with rice-inspection agencies and assistance was rendered in checking the work of the rice inspectors so as to insure the proper application of the grades for rice. A formal agreement was entered into with the Department of Agriculture of Texas whereby a rough-rice inspector at Beaumont, Tex., will be licensed under the food products inspection act. The inspector will use the United States grades for rough rice, and his work will be under the supervision of this bureau. Demonstration work was done which resulted in the rice trade gaining a better understanding of the Federal grades for rice and which has also resulted in the establishment of more rice-testing laboratories by rice millers and others.

GRAIN AND RICE HANDLING STUDIES

Investigations were conducted to determine the effect of combine harvesting on the quality and market value of grain. These investigations disclosed the fact that the combines were frequently harvesting grain before it was ripe, too soon after rains, and too early in the morning, with a result that such grain contained a high moisture content, which causes it to go out of condition in storage and during transportation, results in a lower grade when the grain is graded on the terminal market, and brings a reduced price. It was determined that the grain in the hard winter wheat belt is seldom dry enough for safety in combining until about 10 a. m., and that the grain in the spring wheat belt is seldom dry enough to combine until noon. In the spring wheat belt it was found that the weed seeds which are harvested with the grain are very high in moisture content, frequently testing up to 60 per cent moisture, and that to assure safety in storage the weed seeds must be cleaned out of the grain immediately after it is harvested.

Experiments with ventilated farm grain bins in the spring wheat area demonstrated that when the ventilators are properly constructed, open to the outside air at both ends and spaced close together in the bin, they will keep grain which contains a slight excess of moisture from going out of condition in storage, but may not prevent spoil-

age if the grain is immature or damp or if it contains green weed seeds.

Bulk-handling investigations on the Pacific coast were continued. As a result of the publicity that was given through bulletins, press stories, and illustrated lectures concerning the economy of bulk over the sack method of handling grain, many farmers in that section converted their sack-handling equipment, to bulk-handling equipment, and considerable additional bulk-handling equipment and storage was also installed and built at the country grain-buying points and at the terminal markets on the Pacific coast.

RICE-DRYING METHODS IMPROVED

Extensive investigations and experiments pertaining to artificial drying of rice were conducted both in the southern rice belt and in California. It was found that artificial rice drying as it is often performed commercially injures the milling quality of the rice. Experiments with improved methods of drying demonstrated that rice can be dried successfully so that its milling value will actually be materially improved. Because of the importance of this matter, wide publicity was given to the improved methods that were developed, with a result that the improved methods were generally adopted.

DIVISION OF DAIRY AND POULTRY PRODUCTS

Roy C. Potts, *in charge*

RESEARCH PROJECTS

Research work of the division during the past year has centered on two main projects—the live-poultry market at New York City and the San Francisco wholesale butter and egg market.

The market analysis of the live-poultry industry of New York City has just been completed. This study includes a discussion of the sources of supply of live poultry shipped to New York and of the principal consumers of this commodity in the metropolitan New York area. Detailed analyses of costs of rendering the different services, from shipping point to slaughterhouse, have been made for those States which contribute the greater portion of live poultry coming to this market. The price-making mechanism is described, and the factors influencing price variations have been deter-

mined, and the relative influence of each of the more important price-determining factors has been measured. The report points out the potential advantages to be derived from a union terminal at which all live poultry consumed in New York might be concentrated preparatory to sale.

The study of the wholesale-price situation relating to butter and eggs on the Pacific coast was begun last fall and is well under way. A preliminary report to the trade, which has just been completed, is designed to point out the causes of discontent and to suggest methods of improvement.

Studies on rural per capita consumption of dairy and poultry products and of urban per capita consumption of milk and cream are well under way, and it is expected that the results will appear in published form early next year.

In cooperation with the New Jersey Agricultural Experiment Station a study of consumer habits and preferences relative to eggs in a number of typical New Jersey areas is under way. This study will be associated with a quantitative study of the elasticity of demand for eggs, the preliminary work for which has been completed.

EGG-GRADING SERVICE EXTENDED

Egg-grading services have been maintained during the year in New York, Philadelphia, San Francisco, and Chicago. This work has made advances both in volume of business handled and in its influence upon the egg trade in those markets. New egg-grading services have been established at Boston, Los Angeles, Washington, D. C., and Parkersburg, W. Va. The service at Los Angeles is a Federal-State service and is an expansion of the work previously undertaken with the State at San Francisco. The work at Parkersburg, W. Va., is a Federal-State service which was inaugurated primarily to furnish an egg-grading service for the new West Virginia State poultry demonstration marketing plant located at that point. An agreement was also signed with the State of Virginia providing for an egg-grading service.

Progress in the use of uniform egg grades is indicated by the action of a number of States which have established egg grades based in whole or in part upon the United States standards and grades for eggs. At present eight States (Wyoming, Massachusetts, Maine, Rhode Island, New York, Louisiana, Georgia, and California)

have such grades and others are contemplating similar action.

DRESSED-POULTRY STANDARDS ISSUED

Tentative United States standards and grades for dressed poultry were issued during the year. These have been reviewed at considerable length by members of the dressed-poultry trade and have met with approval in most respects. Some changes have been made as the result of criticism and suggestions received, and the standards and grades are now in shape for hearings to be held on them in the near future.

A grading service was undertaken in Washington as a means of testing out the grades in practical use. Poultry bought under these specifications and officially graded prior to delivery has proven very satisfactory to several institutions in the District of Columbia. An interesting application of this grading service was a sale by a chain-store organization of Christmas turkeys which had been officially graded and stamped "U. S. Prime." This grading and stamping apparently established consumer confidence, for the supply of turkeys handled by this chain had to be augmented while other chain-store supplies, not officially graded and stamped, were not cleaned up although sold at a lower price.

United States classes and subclasses for live poultry have also been issued in tentative form. These were put out in anticipation of the need for a basis for exchange trading. More definite grades for live poultry do not seem advisable at this time, but the United States classes and subclasses proposed will provide a basis for such grades when the need for them arises.

All live poultry arriving in New York is inspected for condition of health and for size of crop by inspectors licensed by this bureau and working under the close supervision of one of its representatives. This work is carried on in cooperation with the New York Live Poultry Commission Merchants' Association and the Greater New York Live Poultry Chamber of Commerce. During the calendar year 1927 over 12,000 cars of poultry were inspected in addition to large quantities of coop poultry arriving by express.

A very interesting new development of the year was the inauguration of an inspection service on dressed poultry and edible products thereof for condition and wholesomeness. This service

was first undertaken for a manufacturer of chicken soup for export to Canada, since without Federal inspection of the poultry used in its manufacture this soup could not be admitted to Canada. The Secretary of Agriculture promulgated rules and regulations and the work was begun in March, 1928. The work covers the complete inspection of each poultry carcass, all those found diseased or otherwise unfit for human food being condemned and destroyed.

Recently the Department of Health of the City of New York amended its regulations to require that, after August 1, 1928, all canned poultry sold in New York City shall have been inspected by an agency acceptable to it. Widespread use of this service may well be the means of establishing greater consumer confidence in canned poultry products and may lead to an increased total poultry consumption. The inspection itself is performed by qualified veterinarians, and the work is now carried on in cooperation with the two organizations which cooperate in the inspection of live poultry at New York.

BUTTER AND CHEESE GRADING

Grading services on butter were conducted during the year at New York, Chicago, Washington, Philadelphia, Boston, Minneapolis, Duluth, San Francisco, Los Angeles, and Bellingham, Wash., and on cheese at all of these points except Duluth and Bellingham.

Principal attention during the year has been given to promoting the efficiency of the work already established. Perfection of new systems of record keeping and closer following up of fee collections have been important steps taken. Also definite work has been directed toward closer maintenance of the same quality standards at all grading points.

At nearly all points the volume of work handled has increased. The total amount of butter graded during the fiscal year approximated 140,000,000 pounds, a larger quantity than ever before, and an amount representing about 10 per cent of the total production of creamery butter in the United States.

MARKET NEWS SERVICE

There are at least two distinct classes of users to be served with market information relating to commodities covered by the division, and while the scope of the service was not materially

expanded, such modifications were made from time to time as were needed to meet the demands of these two groups. The type of service demanded by dealers and distributors in the wholesale markets is first of all promptness, with considerable detail relating to conditions in certain important local markets. Storage reports have come to be regarded as more essential than ever before in the business of buying and selling. Future trading has also increased the interest in storage reports, with the result that effort is now being put forth to provide storage reports which are adequate. Daily and weekly reports covering a large number of the more important storage centers which have been issued over a period of several years now afford the means whereby estimates of total United States holdings may be made by the trade with a close degree of accuracy. Other reports which require promptness in order to meet trade demands are those relating to supplies, and the tone and price trend in important markets. This demand is being met so far as the most important national markets are concerned.

The second class of users of market reports includes creameries, cheese factories, jobbers, grocers, hotel and restaurant buyers, cream-station operators, producers, and others who need in a more general way to keep in touch with market-price information as an aid in checking buying or selling operations. Through its leased-wire service and mimeographed reports the bureau is aiding both of the groups mentioned.

Dairy and poultry trade papers are making extensive use of market reports, in many cases printing reports in full or in part, but also using freely the statistics shown in reports in the making of their own analyses of market conditions. The commercial press and radio also serve as further means of disseminating market information.

Market reports are prepared and released to local mailing lists from Washington, D. C., and eight field offices. The approximate number of names on these combined mailing lists is 20,000, and during the year approximately 5,500,000 mimeographed market reports were distributed. The greatest increase in demand during the year has been for the monthly review which covers all dairy products and summarizes the general dairy situation. There has also been an increased interest in

monthly estimates of butter production, which reports have been of added value this season on account of domestic production being lighter and more uncertain than might be expected.

Preliminary arrangements were inaugurated during the year for milk and cream market reports at Boston and Philadelphia, similar to the service already in operation at New York. The arrangements at Boston were not completed on account of traffic conditions having been so seriously interrupted during the fall of 1927 by floods in principal New England producing sections. These reports will begin with the calendar year 1929. At Philadelphia final arrangements will necessarily include reports from the local milk trade of the quantities of milk and cream received by auto truck. Arrivals by this means of transportation constitute an important part of the city's supply. At Chicago all of the preliminary contacts have been made for the inauguration of a live-poultry market-reporting service similar to the service at New York City.

California has been added to the list of States cooperating with the division in the collection and compilation of statistics on the production of manufactured dairy products. Through this type of cooperation with those agencies in the States which are familiar with local conditions and which furthermore are in many cases authorized by State law to collect information from manufacturers, improvement in dairy statistics should result.

COLD-STORAGE REPORT SECTION

WM. BROXTON, *in charge*

During the current fiscal year a survey of refrigerated warehouse space was made, and the cold-storage bulletin was rewritten and brought up to date as of December 1, 1927. The tabulation showing the warehouse space will be published in the cold-storage bulletin.

There has been an increased demand for the information compiled by the section in the cold-storage report and also for the statistics of slaughter. Mailing lists have been increased, and a large number of special tabulations have been made for various organizations which are interested in using this information for research. Four trips have been made into the field, and several hundreds of the cooperating concerns have been visited for the purpose of bringing about closer relations.

DIVISION OF HAY, FEED, AND SEED

W. A. WHEELER, *in charge*

SEED-VERIFICATION SERVICE INAUGURATED

The seed-verification service, inaugurated in October, 1927, is meeting a need which has long been recognized by specialists of this bureau and by buyers of seed throughout the country. This service is carried on under the same legal authority as the various inspection services on farm products maintained by the bureau, but it is unique in that the verification does not depend upon a physical examination but on the maintenance of a complete system of records by seedsmen, under the supervision of the Federal Department of Agriculture. The service gives to the buyer of seed which bears a verified-origin seed certificate assurance that the seed purchased by him was produced where stated in the certificate. The origin of every lot of seed covered by such a certificate may, through an examination by a Federal seed inspector of the records of the dealer offering such seed, be traced back to the place where the seed was produced. These records show what disposition is made of every pound of seed which is verified. An emblem in the form of a shield, with the words "Verified-origin seed" superimposed upon the letters "U. S.," was adopted for the use of the verified-origin dealers on letterheads, tags, advertisements, etc., which serves to identify these dealers from others not enrolled in the service.

The service was inaugurated on alfalfa, clover, and seed corn, but for the coming fiscal year it has been agreed to limit it to alfalfa, with the stipulation that all lots of this seed, so far as possible, will be verified as to origin. This service is based entirely on voluntary agreements entered into by the seed dealers with this department. The plan of the service lends itself to the verification of all kinds of seed, and it is expected that after the merits of verified-origin seed become better known other kinds of seed will be included in the service.

Sixty-one dealers in 24 States, who usually handle at least 85 per cent of the alfalfa and clover seed sold commercially in this country, enrolled in the service for the first season. Approximately 1,200 inspection certificates, representing nearly 10,000 lots of seed, were handled by six inspectors located in Chicago, Kansas City, Min-

neapolis, Salt Lake City, San Francisco, and Washington. The service was carefully supervised, and information gathered in producing districts, from retail dealers, and other sources, was used in checking the records of the verified-origin dealers. No instance of willful misrepresentation of the origin of seed on a verified-origin seed certificate has been found. This indicates a splendid spirit of cooperation, which is making the certificate a guarantee as to the reliability of the statement of origin contained therein.

SEED REPORTING SERVICE

Four types of seed reports were issued throughout the year, namely, outlook, price and movement, shipment, and weekly seed reviews. In addition, reports on retail prices, a prospective-demand report, a retail-sales summary, and a special report on certified seed potatoes were issued. Special reports on vetch and ryegrass seed elicited favorable comment from far-Western growers. Contact with more than 100 foreign correspondents yielded valuable information, not otherwise obtainable, for the seed reports. Approximately 191,000 copies of mimeographed seed reports were issued, which were widely distributed among seed growers, consumers, and the trade.

HAY STANDARDIZATION

Special attention has been given to providing information for producers, country shippers, distributors, and consumers of hay on the use of and benefits to be derived from the United States hay standards and the Federal hay-inspection service. Bulletins, articles, and press releases of a very practical nature have been prepared, which deal with the marketing of hay on Federal standards, how to purchase alfalfa for dairy feeding, the relation of the United States grades to feed value, etc. An educational campaign was organized among the producers of alfalfa, in order to furnish them with advice as to the best methods of producing and shipping alfalfa to obtain premium prices. Research work is being carried on in the bureau, and many laboratory tests are made of hay produced and handled under varying conditions. The Extension Service of the department and the State agricultural colleges and county agents in the leading hay-producing sections have assisted in this educational work. A marked increase has been noted in the number of livestock feeders who

are placing their orders for hay on the basis of the United States grades.

Important work has been done the past year in the development of new apparatus for measuring the color of hays. The objectives sought are a higher degree of accuracy and a simplification of the methods for determining the percentage of green color in hay. Apparatus has been devised which occupies much less space than the apparatus previously used and which makes use of artificial light, which provides light of equal intensity from day to day or at different times during any one day. The research work on methods and equipment accomplished the past year indicates the possibility of making color-measurement equipment available for use in colleges and supervisors' offices at much smaller expense and taking up less space than heretofore.

SOY-BEAN HAY STANDARDS

A cooperative agreement has been entered into with the Alabama Polytechnic Institute for the purpose of formulating United States standards for soy-bean hay. The Alabama college assembled soy-bean hay bales of different varieties and grades, which have been analyzed and studied in the division's laboratory at Washington. This work was organized at the request of the Alabama Farm Bureau Federation for the purpose of stimulating greater interest in this important forage crop in the Southern States. Several other Southern States have indicated their interest in this project and will cooperate in studying the assembled samples and data for the purpose of formulating the tentative standards.

HAY-GRADING DEMONSTRATIONS

In cooperation with various agencies, hay-grading demonstrations have been conducted in a number of the leading hay-producing States. Hay-judging contests were held under the supervision of this bureau at the Chicago International Livestock Show and at the Portland Livestock Exhibition. These practical demonstrations are very popular and serve as an excellent medium for the dissemination of information on hay grading. The demand for type samples of hay on the part of hay exchanges, hay inspectors, agricultural colleges, and others has increased greatly, and many hundreds of samples have been distributed from the laboratories in Washington and Kansas City.

MEASURING HAY IN STACKS AND MOWS

Ten of the important western hay-growing States cooperated with this bureau in obtaining data from the measurement of approximately 1,000 stacks of alfalfa and other hay, for the purpose of devising an accurate rule for determining the volume of hay in stacks and the number of cubic feet of hay necessary to make a ton under varying conditions. The work so far indicates the possibility of formulating more accurate volume rules than are now available, and it has been agreed to continue the work during the coming year. Large quantities of alfalfa, especially, are marketed in the stack, and accurate rules of this character are greatly needed. Livestock feeders and hay growers are displaying much interest in this project.

ALFALFA-MEAL STUDIES

In response to urgent requests from western alfalfa growers, study is being given to the formulation of standards for alfalfa meal. An item of \$5,000 was included by Congress in the appropriation act for the fiscal year 1929 for this purpose. Preliminary work has been done on assembling samples and in devising methods and equipment for determining moisture content. Study will be continued during the year on grade factors, such as color, moisture, fiber, and protein, and on the problems connected with the milling and shipping of alfalfa meal.

HAY INSPECTION SERVICE EXPANDED

The Federal hay-inspection service has expanded at a rapid rate. The total number of inspections made during the year was 29,343 as compared to 17,161 for the year ended June 30, 1927, or an increase of 71 per cent.

The outstanding development in the hay-inspection service was the addition of Kansas City to the list of markets making use of the service. Kansas City is the largest hay market in the United States, receiving from 25,000 to 30,000 cars annually, of which receipts 80 per cent is distributed to Southeastern and Eastern States. The inspection service at Kansas City, therefore, will have an influence in a large number of the important hay-producing and hay-purchasing States. Other developments of importance were the adoption of the United States hay standards as the official standards in the State of Alabama and the organization in that State of a manda-

tory Federal-State inspection service in the important market of Birmingham.

The Federal hay-inspection service is now operating in 16 terminal or reconsignment markets and at 19 shipping points. Licensed Federal inspectors are also stationed at 26 United States Army posts, where hay is received for the Army in considerable quantities. Federal-State hay-inspection agreements are in force in 6 States. The number of designated and licensed inspectors is 83, of whom 11 are employees of the United States Department of Agriculture engaged in supervisory or research work.

STANDARDS FOR BEANS AND SOY BEANS

Educational work has been carried on in cooperation with the American Wholesale Grocery Association and others to acquaint the trade with the advantages of buying beans on the basis of the United States standards and the United States inspection certificates. The number of shippers' and growers' organizations using this service is constantly increasing. Studies of the factors affecting the quality of beans in storage have been continued in cooperation with the Navy Department. This bureau cooperated with the Bureau of Plant Industry in a study of the efficiency of combines in the harvesting of soy beans. Special attention was given to the effect of this method upon the grade of the product under varying conditions.

INSPECTION OF BEANS AND SOY BEANS

The total number of cars of beans inspected was more than double that of the preceding year. The largest number of inspections and the greatest increase were in Idaho and Colorado, where it was necessary to train and license additional inspectors. The service was inaugurated under cooperative agreements with trade exchanges at New York City and Houston, Tex., and negotiations were entered into for inaugurating the service at Toledo, Ohio, and New Orleans, La. The number of inspections made for the Navy and Marine Corps increased also, and substantial savings to those departments were effected. The total number of inspections of soy beans showed a decrease for the year, but the number of inspections at certain points increased. The inspection service was extended to include Peoria, Ill.

GRAIN, HAY, AND FEED MARKET NEWS SERVICE

The demand for the extension of the grain, hay, and feed news service to additional areas was partly met by a wider distribution of the weekly and special market reviews. Requests for the reviews were received in larger numbers from individual farmers and others, but distribution continued to be effected principally through the press, by radio, in market reports of State agencies, and upon bulletin boards of banks and cooperative associations. The dissemination of the grain-market reviews is now nationwide. The hay and feed reviews are distributed through most of the territory east of the Rocky Mountains. Distribution of special feed-market information has been obtained through cooperation with State marketing agencies in Wisconsin, Minnesota, the principal New England States, and Alabama.

Particular attention was given to making the information more definitely applicable to specific sections of the country. This was accomplished to a large extent by special reports, prepared at pivotal periods during the marketing season. Such reports were issued upon the market situation for durum wheat, rye, flax, barley, feed grains, soft winter wheat, linseed meal, cottonseed meal, wheat feeds, alfalfa meal, and hay. Monthly and quarterly reviews were issued regularly covering the general market situation for grain, hay, and feed more comprehensively than was possible in the weekly reviews. The wheat-protein price service inaugurated in the Minneapolis office chiefly for the Montana State College of Agriculture has been extended to other areas in the Northwestern States.

Progress was made in the development of a statistical foundation for the principal grains and feeds for use in the evaluation of current statistical data and the analysis of current market developments. This involved critical study of the various available market statistics to determine reliability and comparability. With this background it was possible to increase materially the effectiveness of the service and to enlarge the scope of the weekly and special reviews and make them of much greater value to the farmers.

BROOMCORN NEWS SERVICE AND INSPECTION

The inspection and market news service on broomcorn was carried on

during the crop season. Owing to the short crop of broomcorn in 1927 the crop moved quickly at good prices, and there was less demand for inspections. The market news service was placed more definitely upon a statistical basis, and a definite release date, Tuesday of each week, was adopted for the weekly reviews which will be issued regularly from Kansas City instead of from local shipping points. Through a cooperative arrangement with the State Market Commission of Oklahoma a better distribution of the reports to farmers of that State was made possible.

ADMINISTRATION OF THE UNITED STATES WAREHOUSE ACT

H. S. YOHE, *in charge*

The outstanding developments under the United States warehouse act during the year were the drafting of tentative standards for canned vegetables; a specific demonstration of the value of the standard tobacco grades to the farmer; clearer definition of disinterested custodianship of warehoused products; the promulgation of regulations for the storage of cold-pack fruit under the warehouse act, and a tremendous increase in the licensed cotton storage capacity.

The commodities now eligible for warehousing under the act are cotton, grain, wool, tobacco, peanuts, broomcorn, beans, potatoes, sirup, dried fruit, canned foods, cottonseed, and cold-pack fruit.

STANDARDS FOR CANNED FOODS ISSUED

Under authority of the warehouse act, and in answer to specific requests from the trade, tentative standards have been formulated for canned peas, corn, and tomatoes, and drafts of standards for canned beets, stringless or snap beans, and spinach are nearly completed. In these studies the bureau had the benefit of suggestion, counsel, and experiences of various canners, State canners' associations, the standardization committee of the National Canners' Association, and those engaged in governmental purchasing of canned foods or in enforcing laws pertaining to canned foods. Many of the canners in two of the largest vegetable-canning States of the country propose to pack and market their products on the basis of these standards, in the hope that the consumers will ultimately purchase according to these United States standards.

Not only will these standards serve in the marketing of the products, but they perform an important function in financing the canner. Canned foods stored in warehouses operating under authority of the Federal warehouse act will be covered by warehouse receipts which will state the grade of the products. Bankers who finance canners are manifesting a keen interest in the standards, because they afford a more definite means of determining the value of the product upon which loans can safely be made.

TOBACCO STANDARDIZATION

An interesting demonstration of the value to the farmer of the grades developed by the department for tobacco was made at Lynchburg, Va., by the State department of markets. Arrangements were made to grade the tobacco of farmers who desired the service as it was delivered by them at the warehouse. The grading was performed by a State employee in accordance with the Federal standards. The department instructed the State man in the use of the standards and then at various times checked his work to see that the standards were correctly applied and to see just how the standards worked in commercial practice. This demonstration afforded an excellent opportunity to test the practicability of the standards. It also served as a means to impress upon the farmers the need for proper sorting and preparing of tobacco for marketing purposes.

DISINTERESTED CUSTODIANSHIP OF STORED PRODUCTS

One of the first principles to be observed in connection with the financing of commodities while in storage is disinterested custodianship of the product. This principle was early announced in Federal Reserve Board regulations, and leading bankers have repeatedly referred to it. In administering the warehouse act, for the past four or five years, this fundamental principle has been called to the attention of persons desiring to avail themselves of this law, in all cases where it was apparent that the proposed plan of warehousing would not conform to this principle. Because so many plans have been presented to the department which did not comply with the principle, a concrete attempt has been made to offer definite suggestions as a guide to those contemplating using the Federal ware-

house act. These suggestions have been adopted by some leading banks, and the same principle is being applied to commodities other than agricultural. It should be noted that any one seeking credit who is prepared to offer a federally licensed warehouse receipt as collateral which has back of it disinterested custodianship will experience little difficulty.

COLD-PACK FRUIT REGULATIONS

During the past four or five years a number of requests have been received from packers of fruits and from bankers to place cold-pack fruit on the eligible list for storage under authority of the United States warehouse act. On May 26, 1928, regulations for the storage of such commodities were promulgated. Under the regulations cold-pack fruit is defined to mean:

The clean, sound product obtained by packing under certain minimum specifications, in suitable containers, properly matured and prepared fresh fruit and berries, with or without the addition of sugar (sucrose), and by maintaining it at a temperature sufficiently low to insure its preservation.

Because of past experiences it was felt necessary to embody in the regulations certain requirements and restrictions which were new to the packers and handlers of this product. Effort was made, however, to be as liberal as possible without impairing the collateral value of the warehouse receipts. While the regulations in comparison to trade custom may seem drastic, they have been formulated with a view to protecting the storer, the warehouseman, and the holder of the warehouse receipt.

ADDITIONAL COTTON WAREHOUSES LICENSED

Each year since 1920 has witnessed an increase in the licensed capacity for the storage of cotton. On June 1, 1928, the largest capacity was licensed that has been licensed at any one time since the passage of the act. On that date more than 835,000 bales capacity was added to the licensed storage space, making the total licensed capacity for the storage of cotton in excess of 3,435,000 bales. Since that date additional cotton warehouses have been licensed, with the result that there is to-day more federally licensed cotton storage than at any previous date in the history of the Federal warehouse act. It is estimated that more than 50 per cent of the entire cotton pro-

duction of the country will pass through these warehouses.

DIVISION OF STATISTICAL AND HISTORICAL RESEARCH

O. C. STINE, *in charge*

The Division of Statistical and Historical Research has continued collecting information and analyzing problems to provide farmers with information useful in deciding what to produce and when to market their products, and to provide the public with information useful in working out national agricultural policies. The most important accomplishments in the past year have been the collection of more extensive information as to crop and market conditions in the Orient, the production and movement of vegetables from Mexico, and market prospects in continental Europe; and the construction of index numbers of prices of commodities which farmers purchase. Progress has been made in price analysis and in the use of the results of price analysis in production and market-outlook statements.

FOREIGN COMPETITION AND DEMAND

Foreign agricultural production continues to expand and competition in the foreign markets for most of our agricultural products is becoming keener. Owing to increased foreign competition and, in the case of a few commodities, to reduced production in the United States, agricultural exports for the 1927-28 season have fallen below the exports of the 1926-27 season. Imports of agricultural products that compete with the products grown in this country also were somewhat smaller than last year. The outlook at the beginning of the new year is for a continuation of the tendency to increase foreign agricultural production and to reduce foreign demand for the agricultural products of the United States.

The hog producers of the United States probably have suffered more than any other producers in the past year from foreign competition. The recovery of hog production in Germany and the expansion of production in the Netherlands, Denmark, and Ireland greatly reduced the demand for pork and pork products from the United States. The situation has been carefully studied. It has been found that there are cycles of hog production in northern Europe similar to the cycles of production in the United

States. Methods for predicting the cycles in European production as well as in the production of the United States are being worked out. An analysis of the situation indicates that the European demand for pork products from the United States next year probably will be greater than last year, largely because of a reduction in the production of pork. It is clear, however, that the European demand for American pork during the next 5 or 10 years is not likely to be so great as it has been in the past 5 years.

The foreign demand for American cotton of the crop of 1927 was weakened by large exports from the crop of 1926. Domestic exports in the season August, 1927, to July, 1928, amounted to only 7,900,000 bales, as compared with 11,300,000 bales last year. The demand, however, has been greater than indicated by the volume of exports, and the declared valuation of the exports has been nearly equal to that of the previous season. Through the offices of the agricultural commissioner at Berlin and of the agricultural commissioner in the Orient the conditions of foreign textile industries and the demand for cotton in continental Europe and the Orient have been reviewed monthly. According to these reviews, American cotton was consumed at a high rate in many foreign countries during the first half of the season. In the latter half of the season there has been some slackening in consumption of raw cotton and in the demand for cotton goods. The high rate of consumption in the early part of the season, however, together with smaller shipments from the United States, has greatly reduced the foreign stocks of American cotton. Notwithstanding the slackening in consumption, therefore, prospects as to the foreign demand for American cotton at the end of the 1927-28 season are better than at the end of the 1926-27 season.

Civil war in China has disturbed the marketing of tobacco, but the outlook is improving. According to the agricultural commissioner, the cigarette business in China is probably in better condition and looks more promising than at any time during the past year and a half. Improvement in transportation in the heavy-consuming Provinces largely accounts for the restoration of the cigarette business.

Improvement in transportation and stabilization of conditions in China may result in increased exports of

eggs, walnuts, peanuts, and several other commodities. Through the agricultural commissioner, with the aid of the consuls, producers in the United States are being kept informed of developments and prospects as to the shipments from China of agricultural products that compete with the products of the United States, and the producers of agricultural products which we export to China are being kept informed as to marketing prospects.

The European demand for citrus fruit from the United States was somewhat better than last year. An increased volume of oranges and grapefruit was marketed in Great Britain. The first direct shipments were made from Florida to the British market. The fruit-marketing specialist of the bureau is aiding in the development of the market for these fruits in Great Britain by keeping producers and shippers informed of market conditions, by informing shippers of the condition of the fruit upon arrival and by taking advantage of every opportunity to stimulate the demand for these fruits.

The marketing of apples in Europe also has been facilitated by information as to marketing conditions and by advice as to the best methods of handling and shipping the fruit. Two cases of special interest may be cited from the past year's experience:

One incident was the arrival on European markets of considerable quantities of high-quality, low-priced Russian Crimean apples. Trade reports from foreign markets concerning the volume of Crimean shipments, their quality and low prices, alarmed some of the American producers shipping to these markets. The Department of Agriculture specialist, however, immediately cabled that the Yellow Newtown variety of the United States was most directly concerned, but that there was no necessity for any uneasiness, as the available volume of Crimean apples was limited and that the Russian shipments would end by the last of December following the last Crimean apple auction and before large-volume shipments of our Yellow Newtowns ordinarily arrive on European markets.

Another observation of special interest was that early in the season large quantities of barreled apples from the United States were arriving in poor condition, with much overripe fruit and slight decay, and prices obtained were reduced accordingly. In

the first week in January, however, the specialist noted that apples from the same orchards were arriving in excellent condition. The specialist immediately recognized that the later shipments were coming out of cold storage, and therefore advised that next season all apples in the early-season shipments should be precooled. The carrying out of this advice would mean big gains to the American apple producers next season.

The imports of fresh vegetables from Mexico in the winter and early spring are becoming an increasingly important factor in the fresh-vegetable markets of the United States. Shipments of vegetables from the west coast of Mexico to the United States increased from 1,000 cars in the 1920-21 season to almost 6,000 cars in the 1926-27 season. With the aid of the Consular Service a reporting service was inaugurated to keep producers in the United States informed of the conditions of the crops on the west coast of Mexico and of the volume of shipments. Producers and consumers in the United States were kept informed throughout the season of shipments and prospects for shipments in order that they might adjust production and marketing of the early vegetables produced in the United States for market in the period from November to June, in view of the competition from Mexico. Arrangements have also been made to secure similar reports from consular offices in Cuba, Bermuda, and the Bahama Islands. These reports, together with those on the Mexican west coast, provide a well-rounded service on the foreign competition of early vegetables.

The world's 1927 wheat crop amounted to 3,539,000,000 bushels, as compared with the 3,421,000,000 bushels produced in 1926. A comprehensive statistical survey of the wheat situation was issued monthly throughout the year. Early in the season, as it became evident that the crop would be as large or larger than the preceding crop, world market prices declined. Analyzing the situation, this bureau pointed out that while the world's wheat crop was somewhat larger than last year, the prices for the year should average close to those of the previous season because the European rye and potato crops were small, and the world's feed-grain supplies were so short as to result in higher prices which would increase the demand for wheat. Furthermore, it was pointed

out that the poor quality of the crops of Canada, France, and Germany would offset to some extent the increase in supplies. The differences in the situations in the marketing of the different classes of wheat were recognized. It was pointed out that the foreign production of durum was larger than last year and, therefore, the foreign demand for this wheat would probably be weaker. Producers of soft red winter wheat were told that the supplies would scarcely be sufficient for domestic requirements and that the market for this wheat would probably be above the world market level for a part of the year at least.

The farm price of all wheat for the marketing season averaged about \$1.22 per bushel, as compared with \$1.23 for the 1926-27 season. The price of durum declined early in the season and remained low, No. 2 amber durum at Minneapolis averaging \$1.53 in July and at the end of the season in June averaging only \$1.31 per bushel; soft red winter wheat rose to high levels toward the end of the season, No. 2 red at St. Louis rising from the July average of \$1.41 to an average of \$1.96 in May. Correspondents have indicated that at least some producers of durum wheat profited by the analyses of the durum wheat situation by selling early in the season. Many of the soft red winter wheat producers would have profited greatly by holding a part or all of their wheat until the latter part of the season.

Research to provide a basis for increasing the accuracy of early estimates of wheat production in foreign countries has been continued. In 1927 the Argentine crop was estimated accurately about a month before the Argentine official estimate was published. Preliminary studies indicate that it will be possible to estimate the Australian and Canadian crops fairly accurately before the official reports are made.

LONDON OFFICE

An outstanding contribution of the London office of the bureau during the past year was a statement covering the British economic situation as it affected the demand for American agricultural products for use in the preparation of the 1928 outlook report. This statement dealt comprehensively with the present and probable future British demand for such staple commodities as cotton, tobacco, and grain,

as well as for numerous minor products.

Cabled reports on the London wool sales and on the Mediterranean almond situation were particularly valuable. The wool cables covered regularly the prices, activity, and general tone of the London sales, which have an important bearing on world wool prices and consequently upon prices of wool in the United States. The reports on almonds covered the production and price situation in the Mediterranean producing countries and were of value to United States almond growers. A foreign-service release of the bureau, based on reports from the agricultural commissioner in London after a tour of the Mediterranean almond-growing countries, was reissued by the California Almond Growers Exchange and sent to all of its members.

BERLIN OFFICE

During the past year the Berlin office of the bureau has submitted regular monthly reports on the continental European demand situation in respect to cotton, wheat, tobacco, and apples. Monthly reports on the economic conditions in continental Europe as they affect the demand for American agricultural products have also been received from Berlin. A particularly valuable feature of this reporting service has consisted of the supplementary cables which arrive at about the same time as the written reports and bring the information in the latter up to the latest possible date.

An excellent example of the service rendered by the Berlin office may be found in the work on prunes. The principal competition encountered by American prunes in foreign markets comes from Yugoslavia. Reports from Berlin have kept American prune producers and exporters reliably informed on the prospects for shipment of Yugoslav prunes to competitive markets. This service is now being supplemented by cabled reports on the market situation in Hamburg, the leading European market for both American and Yugoslav prunes.

THE ORIENT

A good foundation has been laid for a reporting service on agricultural products in the Orient. The United States agricultural commissioner in that area forwarded a number of basic reports covering the oriental markets

for American agricultural products and on the production and marketing of certain oriental products that compete in our domestic markets. Several reports dealt with the factors affecting the demand for American wheat and wheat flour in China and Japan. A regular monthly reporting service has been arranged, with the cooperation of the United States Consular Service in China and Japan, to keep American wheat producers and exporters posted on the demand situation in the oriental markets. The service consists of cabled reports from Shanghai, Tientsin, Dairen, Harbin, and Tokyo, covering the prices of wheat and wheat flour in these markets, the imports from the several competing countries, and such other factors as affect or reflect the market situation in relation to American wheat and flour imports. Estimates of the condition and probable yield of wheat in Japan and China will be included as the information becomes available.

Reports were received from the agricultural commissioner also on the oriental markets for cotton and tobacco. In view of the fact that Japan is the third largest market for American cotton and China one of the largest markets for American tobacco, it is important to have prompt information on the demand situation in those markets. Arrangements are being made to secure this information each month by cable or radio.

Regular monthly radio reports were received during the past season on the shipment of Chinese peanuts to the United States and the peanut market situation in China. Arrangements have been made for timely cabled reports on the prospects for the Chinese walnut crop and the shipment of walnuts to the United States. Written and cabled reports were received also on a number of miscellaneous products such as soy beans, rice, and egg products.

PRICE INDEX NUMBERS

With the cooperation of other divisions of the bureau, new index numbers of prices paid by farmers for what they buy have been constructed. These index numbers show changes in prices since 1910 of commodities purchased by farmers for the family living and for operating the farm. They are constructed with the same base and as nearly as possible in the same manner as the indices of prices received for farm products.

The ratio of the index number of prices received for products sold to the index number of prices paid for commodities farmers purchase will hereafter be used instead of the ratio of farm prices to nonagricultural wholesale prices as a measure of the purchasing power of farm products.

The level of prices paid by farmers reached the highest point in 1919 and 1920, when it was 206 per cent of the pre-war level. Prices then declined until January, 1923, when the level of prices was only 150 per cent of the pre-war price level. Prices paid by farmers reached their highest post-war level in 1925, when they were 159 per cent of the pre-war level. Since 1925 the level of prices paid by farmers has declined slightly to 154 per cent of the pre-war level in 1927 and recently advanced to 156 in June, 1928. The advance in feed prices during the spring of 1928 was largely responsible for the rise in the level of prices paid by farmers.

Prices of commodities farmers purchased for use in production were lower than prices of commodities used for the family living. The June prices of commodities used in production were 148 per cent of the pre-war average, while the prices of commodities used for the family living were 162 per cent. The relatively low prices of feedstuffs and fertilizer held down the average prices of commodities used in production. Farm wages, however, are relatively high, being 170 in June, and combining wages paid to hired labor and prices paid for commodities raises the index of the cost of these factors in production to 153. The expensive items used by the family are clothing, house furnishings, and building materials. Furniture and furnishings are still about 200 per cent of pre-war prices, clothing 180, and building materials 170. Food prices, on the other hand, are relatively low.

The index of farm prices received by producers for their major products has been continued as in the preceding season. For the 1927-28 season it registered a considerable advance, rising from 130 in July, 1927, to 148 in May, 1928, and to 145 in July, 1928. This advance was due largely to advances in cotton and cattle prices during the first part of the season and to rapidly advancing cattle, hog, and grain prices toward the end of the season. The decline after May was due to considerable declines in wheat, fruit, and vegetable crops. The out-

standing features in agricultural prices during the past season were as follows: The rise in cattle prices on the upward side of the cattle price cycle; the decline in hog prices, which reached their low points around December and January, and a subsequent marked advance apparently on the upward side of another hog-price cycle; a marked advance in grain prices in April and May, due to poor crop prospects, and a subsequent decline due to improvement in crop conditions in the United States and other countries; and further declines in potato prices to pre-war levels, due to the heavy markets from the 1927 good-sized crop and prospects for a very large crop in 1928.

Largely as a result of this advance in the general average of farm prices the power of farm products to purchase commodities the farmer buys improved materially in the past year. The rise in farm prices from 130 at the beginning of the season to 145 at the end was accompanied by a change in the new index of retail prices paid by farmers for commodities bought in June from 155 in June, 1927, to 156 in June, 1928, indicating a relative purchasing power of farm products of 84 per cent of the pre-war purchasing power in June, 1927, and of 93 per cent in June, 1928. However, a good part of this advance in the buying power of the farmers' price per unit was offset by the fact that farmers sold fewer units of such commodities as cattle and cotton.

AGRICULTURAL INCOME

Research aiming at improvement and expansion of the statistical estimates of agricultural income has been continued. In cooperation with other divisions of the bureau, considerable progress has been made toward estimating annually agricultural income by States, on the same basis as that of the United States.

The agricultural income of the United States for the 1927-28 season was somewhat better than for the 1926-27 season, but not quite equal to that of the 1925-26 season, which was the best since the beginning of the depression. Gross income increased about 1 per cent, and expenses remained about the same, resulting in an increase of about 7 per cent in net income available for all capital employed in agriculture and to pay farmers for managing the industry. The average income available for

capital, labor, and management per farm family increased from \$862 to \$886. It is estimated that the rate of return earned on the current value of agricultural capital increased from 4.3 to 4.6 per cent, as compared with 5.2 per cent for 1925-26, which was the highest rate earned since the beginning of the depression.

It is to be observed also that the current value of agricultural capital increased for the first time since the depression. The current value of agricultural capital at the end of the 1928 season is estimated at \$58,431,000,000, as compared with \$58,299,000,000 at the end of the previous season. This increase, however, is due to an increase in the value of livestock, offsetting a small decline in the valuation of real estate.

PRICE ANALYSIS

Price analysis as a basis for formation of policies with reference to the production and marketing of agricultural products has continued along several lines. In the past year most attention has been given to cotton. The marked decline in prices beginning early in September focused attention upon the cotton situation. A thorough analysis of supply and demand conditions early in September indicated that the average price for the season of spot Middling cotton at New Orleans would be a little less than 20 cents per pound, and the price averaged 19.98. A test of the possibility of accurately analyzing conditions with reference to cotton as a basis for planning production has been made with reference to the acreage of cotton for the 1928 crop. By using methods developed for estimating changes in acreage in January it was conservatively estimated that the 1928 acreage would be 10 per cent greater than the 1927 acreage. The actual estimated increase as of July 1 was 11.4 per cent.

Some progress has been made in analyzing fruit prices. Data have been collected in New York and Boston to determine the trend of the demand for apples and for several different varieties of apples. A study has been made of the relation of prices of boxed apples to those of barreled apples and of the effect of foreign demand upon prices. It has been generally known that the annual variations in the prices of apples in the United States have been due largely to variations in the total apple crop

of the United States. The analyses carried on so far supply a method of measuring quantitatively the effect in cents per bushel on the price received by producers caused by specific variations in supply. A study of monthly prices has brought out the fact that the course of prices received by producers for the country as a whole is generally upward after September or October, and that the extent of the rise is considerable or moderate, depending on whether prices around September are much or only slightly below the average level for the year.

Preliminary studies have also been made of factors determining the yearly average prices received by producers of peaches, cranberries, and potatoes. In the case of the last two commodities, as in the case of apples, the size of the crop is the dominant cause of the yearly price variations, and the studies developed so far make it possible to measure the amount of price change that may be expected as a result of a specific change in the size of the crop.

A thorough analysis is being made of corn prices. The object is not only to determine what factors affect the prices but to obtain a measure of the influence of each of the factors annually and monthly. A preliminary report of the research in analyzing corn prices will be available for publication within the next year. It will show, among other things, that the price of corn is determined not only by the size of the corn crop but also by the number of animals to be fed and the production of oats and barley.

TRANSPORTATION

In the past year major emphasis in transportation research has been given to the preparation of material requested by farmers' organizations and others engaged in presenting transportation problems before the Interstate Commerce Commission. A preliminary study has been made of the transportation of cotton, and an index number of cotton freight rates has been constructed for the period 1910 to date. Plans have been made for more extensive research as to the relation of freight rates to the marketing and production of farm products.

HISTORICAL RESEARCH

Historical research continues to be directed toward the collection of information for use in the analysis of causes of shifts and changes in agricultural production and income.

Research to develop a long-time series of farm prices in Virginia and Maryland has been continued in co-operation with the State experiment stations of the respective States. The bulletin containing Maryland prices from 1850 to date, together with analysis of these prices, is about ready for publication. From Virginia records, prices have been obtained for some commodities annually and monthly from 1801 to 1927. A satisfactory series of prices has been obtained for some products, such as tobacco, for which price data have been almost completely lacking. Auction-sale prices of dark fire-cured tobacco, monthly, have been compiled for 100 years—1827 to 1927. An index number of prices farmers received in Virginia is being constructed. The several price series will be published by the Virginia Agricultural Experiment Station.

DIVISION OF AGRICULTURAL FINANCE

NILS A. OLSEN, *in charge*

RURAL CREDIT

The work in rural credit has included analysis of the farm-credit data obtained from studies conducted in co-operation with the agricultural colleges of North Carolina, South Carolina, Georgia, Arkansas, and Oklahoma. These studies bring out current credit conditions and show the relation of the amount and terms of borrowed funds to the source and purpose of credit on the one hand and to the type of farm organization on the other. Studies in three local areas in Arkansas reveal, for example, wide differences in the farm-mortgage interest rates being paid by farmers in the same community and indicate that many farmers could materially reduce the cost of their mortgage credit by availing themselves of the facilities of the Federal farm loan system or other similarly favorable loan plans. In numerous cases the rates now paid are double the most favorable rates in force on other farms.

Analyses of the short-term credit operations of the farmers in North Carolina, South Carolina, and Georgia showed that here again the chief differences in credit cost are due to the source of credit. Merchant credit averaged 27 per cent a year, as against 9 per cent for that of banks and credit corporations. Save in those cases where local cash-credit facilities are inadequate, the farmer can reduce the

cost of short-term credit by qualifying for lines of credit with cash lenders. Analyzed by purpose of credit, it clearly appears that the item of fertilizer was much the most costly from a credit standpoint, both with respect to total outlay and the rate paid. A study of livestock credit in Montana was completed also during the year in cooperation with the State Agricultural College of Montana.

A study directed to the determination of the factors affecting credit costs to farmers in the Southeastern States mentioned indicated that the items of net worth of the farmer and value of production per acre were most closely related to the cost of the credit used. The degree of the farmer's self-sufficiency, percentage of production from livestock, and amount of short-term credit borrowed appeared to have much influence on the rate charged. Inquiry into the operations of agricultural credit corporations in some local areas revealed a tendency for these agencies to appear in emergencies to supplement loan facilities of existing agencies and to disappear or decline in importance when the principal period of stress had passed. A striking feature disclosed in all the State studies referred to was the almost total absence of any other investment by farmers save that in the form of land and farm stock and equipment.

During the year the division entered upon a comprehensive project to determine the total farm-mortgage debt of the United States and of the several States. Schedules were sent to all owners of farms in 85 representative counties distributed over the country. This study will supplement the mortgage data from the agricultural census of 1923 by showing the debt on tenant-operated and manager-operated farms as of the census date. The inquiry will also indicate the mortgage debt on all classes of farms as of January 1, 1928. It is expected that the results of this study will be available before the end of the calendar year.

FARM TAXATION

The main part of the work in farm taxation has been conducted in co-operation with a number of the State agricultural colleges, and the results have been prepared for joint publication. In Massachusetts study was devoted to the subject of assessment and the inequalities that have resulted from the present system. Trends of expenditure among the rural sections

of Massachusetts have also been studied. The Michigan study was devoted primarily to a comparison between the income and taxation of various classes of property and businesses in the State. Farm-taxation studies have been carried on in South Dakota, Colorado, and Virginia. The first phase of the study of the farm-tax situation in Virginia has been completed, and a report on the burden of taxation on real estate in that State is being prepared.

New studies of farm taxation in cooperation with State agencies were initiated during the year in New Jersey, Delaware, North Carolina, Iowa, and Washington. A feature of particular interest in connection with these studies is the fact that in Iowa and North Carolina the bureau is co-operating with groups set up by the State legislatures of each of these States to study the tax problem and to report needed adjustments in the State's system. Informal cooperation with several other similar groups has also been a feature of the year's work.

The compilation of a current index of farm taxation by States has been carried through the year 1927. This index is based on reports supplied by farmers on the crop-reporter lists and is checked with the regular reports of various State bodies and with special work that is being done in several of the States. A slight, but steady, increase in taxes paid by farmers for the past few years seems to be indicated by all available information.

AGRICULTURAL INSURANCE

A study of developments and problems in farmers' mutual fire insurance was completed during the year, and the results of this study were submitted for publication as a technical bulletin by the department. The study covers hazards insured against, terms for which policies are issued, relation of insurance to value of property, special problems involved in fire insurance on livestock, maximum risks accepted and reinsurance for larger risks, classification and inspection of property, methods and costs of getting business, methods of collecting such costs from the insured, reserves against unusual losses, standardization of forms and practices, and, finally, a summary of statistical data showing the relative importance or position attained and the underwriting experience of this class of companies in the various States.

Contributions on various farmers' insurance problems were made at the annual meetings of the National Association of Mutual Insurance Companies, the American Country Life Association, and the State associations of farmers' insurance companies of Iowa, Missouri, Kansas, Tennessee, and New York. Assistance and advice on special problems confronting individual farmers' mutual insurance companies were extended through personal interviews and through correspondence with officers of such companies.

Cooperation was continued with the committee on farm fire protection, which was organized in 1926 and is working under the auspices of the National Fire Protection Association. A brief bulletin prepared by this committee, entitled "Preventing Farm Fires," has been published and widely distributed by the association.

A study of the history and present status of livestock insurance in the United States was begun during the year, and some additional information has been gathered on insurance against hail and other hazards to farm crops, as well as on automobile insurance for farmers. The last-mentioned form of insurance on a mutual or cooperative plan has shown marked progress during 1928.

DIVISION OF COOPERATIVE MARKETING

CHRIS L. CHRISTENSEN, *in charge*

Greater progress in cooperative organization among farmers has been made during the last 10 years than during any other period in American agriculture. Not only have the number of associations, number of members, and volume of business increased rapidly but there has also been noticeable progress in the improvement of the legal status of cooperatives, in organization set-up, operating technic, and business efficiency.

From small beginnings but with constant progress, cooperative methods have now been applied to the marketing of all kinds of farm products and to the purchase and distribution of farm supplies. From a concept of cooperation which was little more than a realization of the economic need for changes in the marketing system, the movement has progressed until now there have been built up thousands of small local associations and hundreds of large cooperative marketing and purchasing associations owned and controlled by farmers. The de-

velopment of the large-scale marketing and purchasing associations is a significant feature of the cooperative movement in the last decade. There are now several farmers' agricultural cooperatives each of which sells annually farm products valued at \$50,000,000 or more, and more than 100 associations are in the \$1,000,000 group.

Cooperative marketing of agricultural products and purchasing of farm supplies has now reached the practical-business stage. Farmers generally have found in the cooperative form of business a method well adapted to their needs. The cooperative method is now being applied in the marketing of practically all farm products and in cooperative purchasing, credit, and other fields. This growth can be explained only by the fact that co-operation has rendered a distinct service to the farmers of this country.

The research, service, and educational work of the Division of Cooperative Marketing is based upon the needs of the expanding cooperative movement. Research projects are planned to assist farmers and their cooperative associations with problems of organization, management, financing, accounting and pooling methods, merchandizing, and membership relations. Educational and service work is also carried on in the marketing of agricultural products, cooperative purchasing of farm supplies, and other cooperative activities among farmers.

In the research, service, and educational work of the division it has been the aim (1) to assist in making existing associations more efficient as business units, (2) to assist through regional surveys of production and marketing practices in the organization and development of sound cooperative organizations, and (3) to disseminate correct information regarding the possibilities and limitations of the cooperative method of marketing farm products and purchasing farm supplies.

RESEARCH STUDIES

The research work of the division is directed along four major lines: (1) Study of the development of cooperative marketing associations within each major commodity group. (2) Business studies of individual cooperative associations which have been operating over a period of years. In these studies a detailed critical analy-

sis is made of the organization, membership relations, pooling and accounting methods, financing, management policies, and merchandising practices of individual associations, and of the external economic factors which affect their operations. (3) Research in legal phases of cooperative organization, financing of cooperatives, membership relations, and educational methods. (4) Studies of cooperative purchasing of farm supplies.

COOPERATIVE MARKETING OF GRAIN

The study of farmers' elevators in the spring-wheat area was continued in cooperation with the State colleges and experiment stations of Minnesota, North Dakota, South Dakota, and Montana. Much information concerning the organization methods and operating practices and problems was obtained from nearly 100 farmers' elevators located in this area. Preliminary reports were prepared and published, giving results of the analyses of costs of operation, the protein problem, hedging operations, and other phases of farmer-elevator operation.

A general survey of farmers' elevators in the entire United States was begun and information obtained from a large number of associations concerning their organization methods, operating practices, and financial conditions.

A study of cooperative grain marketing in Canada was completed during the current year. This study brought out the fact that 25 years ago grain producers of the United States and Canada had reached about the same stage of progress in the solution of their marketing problems. Since that time, however, there has been a pronounced difference in the developments that have taken place. The development of grain marketing in Canada has been from local cooperative elevators to cooperative commission companies, then to cooperative line-elevator companies, and finally to large-scale cooperative marketing associations (often referred to as wheat pools) which control country and terminal facilities, whereas in the United States the local farmers' elevator is still the dominant organization. Several explanations are offered for the difference in organization in countries where conditions of production and marketing are understood to be similar. Chief among these reasons are the following: The Canadian crop consists almost exclusively of one variety

of hard spring wheat, grown in a region where production and marketing practices are standardized; the bulk of the crop passes through one city and over one route to eastern and export markets; cooperative marketing experiences of Canadian producers for more than two decades formed a natural setting for the development and successful operation of the present large cooperative grain-marketing associations, whereas in the United States quite the opposite situation prevailed. Other factors which have contributed to the success of the Canadian associations are the fact that the bulk of the Canadian crop is exported; the importance of the wheat crop to the economic life of Canada, particularly the West; the existence of a banking system which facilitates large-scale cooperative activities; and the support of the provincial and Dominion Governments. Important as these and other factors have been, however, it is believed that the achievements of both cooperative elevator companies and the pools are due primarily to the fact that they have been organized in such a way as to coordinate the operation of country and terminal elevators with central selling agencies.

During the year a study was begun which, when completed, will bring together the facts concerning farmers' efforts in terminal grain marketing in this country. A preliminary survey of cooperative grain commission companies and of state-wide wheat-marketing associations or wheat pools was undertaken. This investigation will lay the foundation for a further program and will put both the department and the associations themselves in possession of basic information which is fundamental to an intelligent appreciation of our grain-marketing problems.

COOPERATIVE MARKETING OF DAIRY PRODUCTS

Data have been collected regarding the important types of cooperative fluid-milk marketing associations. This study includes a description and comparison of the organization set-up and operating methods of the various types of fluid-milk marketing associations and economic analyses of individual associations and the environment under which they operate. Special attention will be given to the equitableness of pooling methods and price plans and the effect of the latter in controlling seasonal variation in pro-

duction and the leveling out of periods of excessive and insufficient production.

A study which was begun at the request of 25 dairy cooperatives of New England on economic aspects of the marketing of milk and cream in New England has been completed. The results of the study emphasized the need of coordination in the New England milk industry in production, assembling, converting, shipping, and city distribution. Effective cooperative organization of producers, built upon a firm foundation of ably managed country plants, was recommended as a means of bringing about such coordination.

An economic study of the Lake Michigan west shore milk shed, with special reference to the cooperative marketing of fluid milk, cheese, and butter, has been started in cooperation with the University of Wisconsin.

Cooperative butter and cheese associations have been studied in order to set forth the more important causes for the development of cooperative manufacture and sale of these products. The study will attempt to show, so far as the information can be obtained, the economic conditions which have been responsible for the development of cooperative marketing of these products and to explain the types of organizations that are particularly well suited to production conditions in different parts of the country.

COOPERATIVE MARKETING OF LIVESTOCK

A study of the terminal livestock commission associations was completed and the findings were published. This study covered the organization, operation, services, management problems, and accomplishments of these cooperative agencies and presents a working program as an aid to the associations in planning for further growth and improved service.

Information is now being gathered for a bulletin which will present the organization, working system, and accomplishments of the local livestock shipping associations, together with such current problems as trucking and direct shipping. Especial attention will be given to the experiences of associations which are handling these problems successfully.

To further assist the associations in their educational and extension programs, a motion picture, Cooperative Marketing of Livestock, has been made, which shows in detail the operations of the local livestock-shipping

associations and the cooperative terminal agencies. A slide lecture, series 228, Cooperative Feeder Cattle and Lamb Pools, was also completed during the year in cooperation with the extension division of the department. This covers the operations of the live-stock-purchasing pools which ship live-stock direct from the range to the Corn-Belt feeder.

COOPERATIVE MARKETING OF WOOL

At the request of 30 cooperative associations marketing wool, a study of wool marketing in Australia, New Zealand, and other competing countries was undertaken by the division in March, 1927. The purpose of this study was to acquire information which could be applied to the cooperative marketing of wool in this country. The investigation involved a thorough survey and analysis of the practices and methods of wool marketing in the countries indicated, with special attention to the importance placed on wool types for production purposes, the shearing of the fleece and the manner in which it is handled, and the system of centralizing wool and its shipment to the large markets. The functions and operation of the various wool cooperatives in Australia and New Zealand and the Australian Wool Council were also analyzed. A striking similarity was found in the development of the sheep industry in several of these countries, in some respects, and it is believed that the fact of their uniform success in the production and marketing of high-quality wool has been largely because of the following: Development of breed types, or modification of existing breeds to meet local conditions as to feed, climate, and other factors; preparation of the wool for market in such a manner as to attract the largest possible number of buyers; improved methods of disposal of the clip; development of the cooperative marketing of wool; and governmental support of the sheep industry in that an active interest in this industry was shown by the Governments of all of the countries studied.

COOPERATIVE MARKETING OF COTTON

The division's work with the cotton cooperative associations has involved both research and service. Study is being made continuously of the organization structure and operating methods and practices in the coopera-

tive marketing of cotton for the purpose of assisting the organized producers in determining desirable and undesirable activities and in directing their work along sound lines.

Assistance has been given in the organization of a system of cooperative gins or local units by two or three associations. Interest in the cooperative-ginning field is still great, and considerable progress is being made. A general study of one-variety-community cotton production as practiced in the irrigated valleys of the Southwest was made with a view to properly advising the development of one-variety communities around cooperative gins.

Most of the cotton-marketing associations have operated for one year under a new membership contract, which differs radically in many respects from the old one. Plans are being completed for a cooperative cotton conference to be called by the division to consider future objectives and policies.

COOPERATIVE MARKETING OF HONEY

In order to determine possible outlets and demand for honey, particularly that produced by cooperative associations in the Intermountain States, a survey of market conditions is being made in certain large cities. A part of this project, with reference to market conditions surrounding New York State honey producers, is being carried out in cooperation with the New York State College of Agriculture.

A summary of the preliminary results of the survey of wholesale outlets for honey shows that the following are important factors in the marketing of this product: (1) The chief wholesale outlets for honey are the bottlers, the wholesale grocers, and the chain-store systems. (2) All dealers agree that because it is a luxury product, honey must be standardized and advertised before it will meet a ready demand. However, dealers who are honey specialists report a gradual increase in volume of sales. (3) Consumers have little knowledge of honey, and because the price is relatively higher than that of syrups, jellies, jams, and sugar, they buy the latter. (4) Many styles and sizes of containers add to the cost to the consumer. The survey of retail stores serves to strengthen the general conclusions regarding the marketing of honey which were derived from the study of wholesale outlets.

Education of the public relative to the healthfulness and food value of honey offers one promising solution of the problem. The further development of cooperative marketing among beekeepers is probably necessary to meet effectively the marketing situation here indicated. There is also need for coordination of the activities of all cooperative associations, especially in matters of standardization and advertising.

COOPERATIVE-BUSINESS ANALYSIS

Increasing interest is being manifested in that phase of the research program which deals with detailed critical and intensive studies and analyses of the organization and operation of individual farm-cooperative associations. The studies include a complete survey and analysis of the business policies and practices of an association, its relations with its members and its customers, and the economic environment under which it operates. The division has been able by such studies to be of special assistance to particular associations and to bring together facts relating to the standards of efficiency of all cooperatives.

An economic study of the organization known as the Poultry Producers of Central California was begun late in 1926, at the request of the board of directors of that association. The study involved a thorough examination of the marketing machinery of the association including legal structure, economic organization and operating practices, management, selling program, policies and efficiency with regard to costs of selling, membership relations, and other phases of the business. It was found necessary to include also a very complete analysis of the New York egg market and of the interdependence of this and other large markets for eggs. From the results of this study, a report was prepared for the board of directors of the association, an address was made before a conference of representatives of cooperative egg associations in Chicago, and the results of general interest have been presented for publication.

Some of the most interesting of the findings developed during the study may be summarized as follows:

The association has enjoyed an almost continuous growth in membership and in deliveries by members.

Deliveries seemed to be affected more by production cycles than by relative price changes. There has been a tendency to attempt to shift production so as to take advantage of the high prices attained in

the eastern markets in the late fall. This has resulted apparently in a heavier production of pullet eggs at that time of the year than might otherwise have been the case.

Membership appears to be divided into two classes: (1) Those whose business is largely, if not wholly, the production of poultry products; (2) those to whom poultry production is a side line. The latter group comprises about 58 per cent of the membership and delivers about 76 per cent of the volume.

A survey of the membership indicated a wide general satisfaction with the association and its policies, concerning which the members seemed to be well informed.

The selling policy of the association is to market in the East all eggs of the characteristics which enable them to stand the shipment east. The balance of the production, amounting to somewhere around 45 per cent of the total, is marketed in the local produce area, largely in San Francisco and other cities on the bay.

A business study of the Producers Live Stock Commission Association of National Stock Yards (East St. Louis), Ill., was completed during the year. This association is one of the 25 cooperative livestock marketing agencies operating on the terminal markets. This project was undertaken at the request of the board of directors of the association because it afforded the division an opportunity to study analytically one of the larger terminal livestock marketing associations. The study included an analysis of the organization set-up of the association and of the financial results of its operation. Membership problems were also studied. In this connection the consistency with which members and others had consigned shipments of livestock to the association from year to year was determined. Numerous interviews were had with member and nonmember shippers of the association and others in order to determine their attitude toward the association and its operation. The price and sales policies of the association were analyzed statistically.

Upon completion of the study a report was prepared and submitted to the board of directors of the association. One of the results of this study was the presentation to the board of directors of the National Live Stock Producers Association, at their request, of a suggested program of research for the national association.

At the request of its board of directors, a business analysis of the Rice Growers Association of California was undertaken, which will embrace the problems involved in the marketing of the rough and milled rice of the United States, and in particular the methods followed by the association

in disposing of members' rough rice to domestic buyers and in disposing of the crop surplus as brown or milled rice in foreign markets, principally Japan.

Japan rice is the only class grown commercially in the principal rice area of California, and this is a class of rice acceptable in Japanese export trade. Ample control of the supply of rough rice assisted the association materially to secure contracts with all the milling interests for toll-milling rough rice into brown rice, which was sold to Japan. Through the contract with the millers the association was able to obtain the cooperation of non-member supplies. The export operations cared for the surplus from the large 1926-27 crop, leaving no carry-over into the 1927-28 marketing period, and the domestic price was thereby enhanced. Marketing of the surplus of the 1927-28 crop, however, was materially inhibited because of the large rice crop in Japan, which was accompanied by relatively lower prices in that country, and because of the condition of the California crop, a large portion of which was damaged from early fall rains which occurred during the 1927 harvesting period.

In its usual selling operations the association does not pool the sales returns of its members but permits the members to choose the date and approve the price at which the association sells rough rice. The management of the association, through efficient grading service, current news letters to individual members, marketing credit arrangements, and efficient field departments, has succeeded in maintaining orderly marketing of the members' rough rice. The preliminary results of this study are being used by the division to assist rice farmers through their cooperative associations.

At the request of a group of organizations and agricultural leaders in Virginia, North Carolina, and South Carolina, a study was undertaken to determine the cause of the failure of the Tri-State Tobacco Growers' Cooperative Association, with a view to obtaining facts that will be of use to other tobacco cooperatives in avoiding similar misfortunes and in directing their business operations. Information on tobacco marketing and price data were obtained also from representatives of tobacco warehouses over the three States, and visits were made to about 1,000 farmer-producers.

The study, as it progressed, brought out three major aspects of the situa-

tion with respect to the cooperative marketing of tobacco in North Carolina, South Carolina, and Virginia: (1) Unfavorable social conditions and low standards of living among the tobacco producers; (2) the economic conditions surrounding the tobacco growers, particularly the fact that the majority of farmers are heavily in debt and that most of the tobacco is grown on borrowed capital; and (3) the inherent characteristics of tobacco production and marketing. Certain factors within the association, such as their failure to employ a full-time executive, extravagant expenditures, price and sales policy, and redrying policy, contributed to the failure of this particular association rather than the real obstacles to the permanent development of the cooperative marketing of tobacco.

Circular No. 10, entitled "Joint Use of a Sales Organization by Two Cooperative Associations," based on the study of the joint-sales arrangement whereby the deciduous fruit of the California Fruit Exchange is sold through the sales organization of the California Fruit Growers Exchange, was completed and published.

MEMBERSHIP RELATIONS AND FIELD SERVICE PROBLEMS

To obtain information on which to build more effective field service and educational programs through study of the membership problems of cooperative marketing associations, a series of surveys of membership relations was begun in 1925 with the study of certain large tobacco and cotton cooperative associations. This project was continued in 1926-27 by the study of the membership problems of four large fluid-milk cooperative marketing associations, in cooperation with the Ohio State University and Cornell University. A preliminary report of this study was made to the associations. On the basis of this report the extension force of the department of rural economics at Ohio State University, together with the officers of the association and the representatives of the Division of Cooperative Marketing, formulated somewhat in detail an educational program for Ohio cooperatives which they have executed in cooperation with the field-service departments of the two cooperatives. Similar preliminary reports were made to the Philadelphia and New York milk cooperatives, and the division has assisted these two large coopera-

tives in formulating in detail an educational program for the 25,000 members of the Philadelphia association and the 45,000 members of the New York Dairymen's League.

Other surveys of this series have been made in connection with the local livestock-shipping associations of Illinois and Missouri. Surveys among the prune and apricot growers' organization of California and the Pacific Co-operative Wool Growers' Association were conducted during 1928. It is planned to cover all of the representative branches of cooperative marketing in these studies and to combine the conclusions reached in a general bulletin on membership relations and field-service problems of cooperatives.

LEGAL PHASES OF COOPERATION

The study of legislation, court decisions, and interpretations affecting cooperation has been continued during the current year, and articles relating to these matters have been prepared and published in *Agricultural Cooperation*, the biweekly periodical published by the division. The division has been represented by its legal specialists in a number of important conferences where assistance was rendered in the solution of the legal problems confronting cooperative associations. A large number of inquiries concerning the organization of cooperative associations and their legal problems have been answered.

FARMERS' COOPERATIVE OIL ASSOCIATIONS

The study of farmers' cooperative oil associations, in cooperation with the University of Minnesota, was extended to include recent developments of cooperative purchasing in that field. Attention was given to the organization, financing, management, and costs of operation of these companies. The results of the extended study are now in process of publication which will make available the experience of these associations for the benefit of groups who plan to organize such cooperatives and for purposes of comparison with other associations already established.

SERVICE AND ADVISORY ACTIVITIES

There is an increasing demand from cooperatives for service and advisory assistance. The staff is constantly being called upon to assist existing cooperative associations with their legal, financing, and merchandising problems, accounting and pooling prac-

tices and to assist and advise committees, and producers who contemplate organization.

The assistance which has been given the American Rice Growers' Association illustrates the type of service which has been rendered to scores of large cooperatives during the past year. Features of this particular project, which deals with the reorganization of the association, include the installation of a rough-rice grading laboratory at Beaumont to provide Federal-State grading service on the basis of the United States standards, market news service to members and exchange sales managers, and standardization of trade practices between localities.

Other examples are (1) the preparation and presentation of a plan for the federation of apple marketing associations in the Nashoba section of Massachusetts; (2) a survey of marketing conditions and the development of a plan of organization for beekeepers in the five Intermountain States—Idaho, Utah, Montana, Wyoming, and Colorado (the Mountain States Honey Producers' Association has been formed in accordance with the findings developed in this survey); (3) the preparation of contracts and assistance in grades and classification for the "feeder pools" of terminal livestock marketing associations (under this cooperative endeavor cattle and lambs are shipped direct from the range to the feed lots in the Middle West); (4) the preparation of a standard set of by-laws for farmers' elevators at the request of a number of farmers' elevators in the spring wheat area.

EDUCATION AND EXTENSION IN COOPERATIVE MARKETING

Short-time schools of cooperative marketing in which the division cooperated were held during 1927-28 in Connecticut, Colorado, Arkansas, Tennessee, Kansas, Missouri, Texas, and Massachusetts. These schools are conducted by State colleges of agriculture and extension services and have elicited the active support of the cooperative associations within the States where they have been held. The average attendance at each of these schools has been approximately 150 persons. Those in attendance have been chiefly directors, officials and field men of associations, county agents, agricultural teachers, and others who have responsibility with regard to the direction of the cooperative movement within their respective States. The programs are designed to

present a general picture of national cooperative development, policies, and problems, but more particularly to give consideration to the needs of the associations and the general marketing problems within the area represented in each school.

The division has also cooperated with the State Board of Vocational Education and the Extension Service in Colorado in conducting a series of 10-day schools or cooperative marketing conferences for farm people. It is the purpose of the division to make the results of its research work and other published material available to teachers in such form as will be most useful to them, not only in conducting schools for farmers and farm boys, but also in strengthening the work in agricultural cooperation which is being given in high schools.

Representatives of the division have taken part in many meetings of cooperative associations, and other meetings of farmers. Much time and assistance have been given in the formulation of State programs for the extension of cooperative marketing among producers. In this work use is made of film strips, lantern-slide lectures, motion-picture films, and exhibits. A series of lessons in cooperative marketing was prepared for broadcasting through the United States radio farm school. Approximately 100 State and national meetings, cooperative-marketing schools, and other important meetings were addressed by representatives of the division.

The results of all studies made are prepared for official publication, either as mimeographed reports or printed bulletins. In addition many special articles and releases are prepared for magazines and other periodicals.

HISTORY AND STATISTICS OF COOPERATION

A count shows that the number of participants in the activities of cooperative associations at the close of 1927 was about 3,000,000. Although some farmers participated in the activities of more than one association, it is estimated that more than 2,000,000 farmers were served by cooperatives during the year.

Technical Bulletin No. 40, entitled, "Agricultural Cooperative Associations, Marketing and Purchasing, 1925," was published during 1928 and is being widely distributed for use as a text in schools and colleges of agriculture and in special courses in agri-

culture and marketing. The bulletin is also being used for reference purposes by bankers, economists, public speakers, and magazine writers and by students, teachers, and public officials in foreign countries. This publication was based on detailed information regarding the 11,400 farmers' business-association records which are on file in the division's library on cooperation, and it contains the most complete statistical and historical information available on the farmers' cooperative movement in the United States. A number of other statistical and historical reports were issued also.

The biweekly circular, *Agricultural Cooperation*, was continued. This publication contained articles covering statistical and other information on cooperative marketing of cotton, fruits and vegetables, dairy products, grain, livestock, nuts, poultry products, and wool, and on cooperative buying and education in cooperation.

DIVISION OF FARM POPULATION AND RURAL LIFE

C. J. GALPIN, *in charge*

Popular interest in farm-population statistics has risen. The continued heavy movement of farm people to cities, accompanied by an increased return movement from cities to farms, has raised several new questions such as the following: Does prosperity for agriculture require a considerable diminution in the present farm population; can cities absorb without distress to farm migrant and city laborer the excess farm population; may it not be necessary for agriculture to retain a lower stratum of farm population of considerable numbers, living on poor lands and restricted to a relatively low standard of living; and is evacuation of poor lands and resettling of farm people on good land feasible?

Work is being done on analyzing the distribution of farm population over land of varying quality in an effort to determine the relation between quality of land, size of farm, etc., and the family standard of living. It appears from preliminary study that a large percentage of the farm population lives on land that is too poor or farms which are too small to make possible a satisfactory standard of living. It is expected that results of the study can be published in the comparatively near future.

RESEARCH STUDIES IN PROGRESS

The sum of \$97,038 of Purnell Act funds has been allocated to sociological research at the agricultural experiment stations of 23 States for the fiscal year just ending. The Division of Farm Population and Rural Life has cooperated in one form or another in virtually all of these research projects. Ten studies were completed and bulletins published by the cooperating agencies. The field work on 14 other studies has been completed or is nearing completion.

In cooperation with the Ohio experiment station and the Division of Farm Management a study was made for the purpose of determining the conditions of farming and of family living in a region of low incomes and low expenditures. It was found that only three out of five of the farms in this area a generation ago are now being operated. Many who now live on farms find part-time employment in the coal mines, work on State and county roads, at oil fields, or in sawmills. Some of the farm homes are now used entirely as a place to live. It was found in this area that after the expenses of operating the farm were paid only about 40 per cent of the average amount of cash available for the family living expenses came from the farm. On the other hand, some of the highest incomes were made by farmers operating farms which had a sufficient acreage of really tillable land and devoting all of their time to farming.

In cooperation with the Division of Cooperative Marketing a research study of the social factors involved in the cooperative potato exchanges on the Eastern Shore of Maryland and Delaware has been nearly completed. It has been found that the social factors are as important to the successful operation of a cooperative association as the physical and economic conditions.

A nation-wide study of rural community buildings, with special reference to buildings built and utilized by cooperative organizations is under way. A study of rural libraries was completed, and the results were published as a farmers' bulletin.

The division has given assistance and supervision to a survey of the active research projects in the field of rural sociology. This survey has

resulted in a valuable monograph of a descriptive and critical character of the work of rural sociological research in the United States.

The usual directory of persons teaching rural sociology in colleges and universities of the United States was issued. The quarterly publication entitled "Farm Population and Rural Life Activities," which is a review of current research and related projects, has proved to be of great value to sociologists. Resolutions were adopted by the rural sociological section of the Sociological Society expressing appreciation of the work of this division and recommending the continuance of the quarterly.

ECONOMICS LIBRARY

MARY G. LACY, *in charge*

The library continued to meet the requests of the public for information on subjects pertaining to agricultural economics, as well as to furnish assistance to the research workers of the bureau and others both in the Government service and outside who are working on economic problems relating to agriculture.

In addition to the circulation of a large number of books and periodicals the library circulates and files current reports covering crop and market conditions. Special files are maintained of information coming from foreign fields. A large volume of correspondence is handled which necessitates reference and research work.

A special feature of the library's work is the preparation of a series of bibliographies on agricultural economics. The series was begun several years ago, and, during the past year, 12 mimeographed bibliographies were issued, besides 35 typewritten reference lists. In addition to serving the needs of the workers in this bureau, these bibliographies are much in demand by agricultural workers throughout the United States and in foreign countries. Many commendations are on file which indicate a growing appreciation of this type of service.

Agricultural Economics Literature, a monthly publication which reviews current books and articles on subjects relating to agricultural economics, has been published throughout the year. Many testimonials as to its usefulness and requests to be placed on the mailing list for it have been received.

DIVISION OF LAND ECONOMICS

L. C. GRAY, *in charge*

LAND RESOURCES AND LAND UTILIZATION

Crop acreage in the United States has remained practically stationary for a decade, the number of horses and mules has decreased 25 per cent, the number of cattle has decreased over 20 per cent, and the farm population has decreased fully 10 per cent. Nevertheless, the increase in agricultural production since the World War has been much greater than the increase in the Nation's population. Is this increasing efficiency in the utilization of the land likely to continue, and will there be no need for more crop land in the near future? The answer to this question is basic to programs of land reclamation and settlement, and to the forest policy of the United States and of several States.

The two major causes of this increased efficiency in land utilization are (1) the substitution of automobiles and tractors for horses and mules, with the resultant release of a large amount of feed for meat and milk animals, and (2) the increasing production of milk and pork per unit of feed consumed. A study of the factors involved in the great increase in animal products per acre of land utilized, both for the United States as a whole and in each of the agricultural regions, together with the shifts in production that have occurred from region to region has been completed.

Another study dealing with regional shifts in crop acreage and in acre yields and the resultant effect on crop production in the United States as a whole is nearly finished. A third study dealing with the changes in agricultural production and consumption in the United States as a whole since 1900 and the consequent changes in land utilization is under way.

An article entitled, "Land-Use Changes Point to Lessening Need of Expansion" was published in the Yearbook, and a summary paper, Population, Food Supply, and American Agriculture was issued; also a study of land utilization in China was published in the journal, Foreign Affairs. The soil section of the Atlas of American Agriculture, prepared primarily by the Bureau of Chemistry and Soils but with the aid of this division and under its general direction, is nearly ready for publication. Land-classification maps of the central Great Plains,

prepared by the United States Geological Survey, Department of the Interior, for the Atlas of the Great Plains, under preparation by the Division of Land Economics, have been completed; and a natural-vegetation and carrying-capacity map of the northern Great Plains is practically finished, as are also a series of maps showing land utilization in the northern Plains by census-enumeration districts. The compilation of data obtained by surveys in the southern Great Plains on settler's progress and land utilization was also completed.

REGIONAL PLANNING STUDIES

This division is cooperating with the West Virginia, Pennsylvania, and Kentucky Agricultural Experiment Stations in studies looking toward the development of more satisfactory land utilization in the mountainous regions of those States. During the past year work has been continued in Colorado and West Virginia and initiated in Pennsylvania and Kentucky.

The fundamental problem consists largely of determining which areas should be in forests and which in farms. The next step involves the determination of what combination of timber growing and farming within the same general area is most economic, and, third, the determination of the most economic combination of crops and timber growing on specified types of farms.

Regional studies in rural planning are intended to provide the basic material prerequisite for the development of agricultural extension programs. In these mountainous regions, particularly in the Appalachians, a transition almost revolutionary is taking place with reference to the use of lands. Many farms are being abandoned, and many farmers are moving into other farming areas or into industry. When the results of the studies in regional planning are available to the extension workers they will be able to give such advice as will eliminate a great deal of the friction incident to the transitional processes and at the same time bring the transition about more quickly.

Results of a regional-planning study in the region of western Colorado affected by the completion of the Moffat Tunnel are being analyzed. In that semiarid region the problem is to ascertain the margin between farming and range grazing, to study the problems of coordinating the two uses, par-

ticularly the problems growing out of the interspersal of large areas of public range land and forest reserves.

LAND-SETTLEMENT STUDIES

In cooperation with the experiment stations of Minnesota, Wisconsin, and Michigan and with the Wisconsin Department of Agriculture, a survey is being made to determine the turnover of settlers in various types of land-settlement projects in the cut-over portions of those States. This is a follow-up study based on a survey of conditions of land settlement in the same area made seven years ago. Attention is being given to the progress in clearing land and in net worth of settlers who are still on these farms. A bulletin designed to aid prospective settlers by describing vacant areas in the United States available for settlement is being revised. A manuscript has been prepared summarizing the results of studies of factors affecting the progress of settlers in the same territory, and another manuscript designed to be published as a farmers' bulletin descriptive of the opportunities for settlement and the problems confronting settlers in the northern Great Lakes region has been nearly completed.

LAND APPRAISAL AND LAND VALUES

The unprecedented declines in farm real estate values during the last seven years have emphasized a phase of our agricultural problem to which formerly little attention was given. The resultant huge losses to individual farmers, to private investors, to the country banks, and to the larger lending institutions of the country, together with the fact that the end of the decline does not even yet appear to have been fully reached, has awakened the country to the importance of having better information on the underlying trends in the farm real-estate market. Accordingly, a principal objective during the year has been to enlarge and improve the annual survey of conditions. More than 20,000 copies of the report of the second survey entitled, "The Farm Real Estate Situation, 1926-27" were distributed. During the same period the number of dealers, bankers, appraisers, and others voluntarily cooperating in reporting on conditions was doubled.

The bureau participated in two land-valuation short courses conducted under the auspices of State agricultural experiment stations. Prelimi-

nary investigations of the availability and adequacy of data compiled by official agencies outside of the Federal Government were made. Two of the States leading in the compiling of actual farm-sales prices as a basis for the equalization of assessments, have virtually abandoned the use of actual sales for this purpose because of the impossibility under prevailing conditions of obtaining enough voluntary sales with which to work. Reliance is being placed upon competent estimates of value, the method which has always been the basis of this bureau's figures. Further advance was made during the year in the preparation of an annual index, which will indicate the extent to which farm real estate values are tending to get "out of line" with their realized earnings and with the rates of return procurable on alternative investments.

Substantial progress was made on studies of various local factors influencing farm real-estate values being carried on in cooperation with the Bureau of Public Roads. Determination of the net effect upon value of buildings, soils, roads, etc., should aid in the development of improved land-appraisal methods and throw light upon the problem of rural-highway finance. Studies of the only available long-time records of land prices—those found in the county deed books—were continued in an effort to ascertain the major movements in farm real-estate prices and the factors which will explain them. A cooperative study with the Minnesota Agricultural Experiment Station of the effect of various local factors on land values in the cut-over counties of the three Lakes States was carried to substantial completion.

LAND TENURE

The study of land tenure in its relation to land utilization in Georgia was expanded to include a section of South Carolina and a few counties in Alabama and North Carolina. The combination of unfavorable economic conditions for cotton production in this area and bad crop seasons has placed the land owners in a position in which it is impossible to operate on the old basis. Work in cooperation with the Kentucky Agricultural Experiment Station on farm-business surveys has been continued.

The study of land tenure in Nevada has been continued in an effort to reach the solution of the problems

involved. The large area of public domain, used mainly as low-grade grazing land, raises many questions as to proper methods of control, kinds of use that will make the best returns, the maintenance of yield of the natural vegetation, etc. These questions concern privately owned lands also that must be correlated with these public lands. Maps showing the present ownership, utilization, and control of the land are being prepared. The local points of view have been obtained by interviewing a large number of ranchers. A study of the development of the laws and judicial decisions related to this subject has been carried on with a view to finding out the kinds of rights which have been recognized and the local methods of control which have been established.

FARM LABOR

A questionnaire was circulated to all parts of the country requesting data as to the amounts of money paid in each month of 1927 to farm labor hired both by the month and by the day, both with and without board. The objects were to obtain more definite information concerning the relative amounts paid monthly and annually to the various classes of labor by the different methods and by the various types of farmers; also to secure a check upon the accuracy of certain farm wage data calculations made in the bureau. Tabulation of these data is largely completed, and the results of the inquiries of the two previous years concerning the perquisites of non-casual and casual farm laborers will soon be available.

Other studies to be reported upon include the agencies of distribution of farm labor in 12 Northeastern States, the farm-labor supply and demand, farmers' methods of handling labor, and the general farm-labor conditions in those States. A statistical tabulation is being made to show the portion of population engaged in agriculture and as farm laborers; also the relation between the population engaged in agriculture and the value of farm property by counties, and the expenditures for farm labor and the part of production which goes to meet farm-labor expenses.

DIVISION OF ECONOMIC INFORMATION

J. CLYDE MARQUIS, *in charge*

The growth in the use of economic facts in agriculture continues. The

results of the bureau's work of spreading information is shown by a steady increase in the number of individual farmers and business men dealing with agriculture who wish to keep informed on changes in agriculture. The growth in demand has been supplied chiefly through contacts with extension agencies, principally the county agents, and other extension specialists. Economic facts are becoming a larger part of the materials used in general farmers' meetings so the change is not reflected entirely by the demands for bulletins.

During the year just completed the contacts between the division and the extension groups have been increased. The head of the division has presented the bureau's work to groups in several States, and conferences of economists, extension directors, marketing officials, agricultural teachers, etc., have been assisted.

The most comprehensive research study of the bureau is the outlook program. The past year has seen the greatest advance in this field since it was started six years ago. By means of the outlook conference in Washington, representatives of over 20 States were informed upon what facts the bureau could provide regarding the general agricultural situation. The State outlook conferences that followed then gave additional distribution to the facts, and the general publicity has stimulated a widespread interest in the bureau's work throughout the country. The preparation of the outlook report, its distribution to the press, to extension workers and farmers, the handling of charts, introduced as an aid this year for the first time, all have added to the work of the Division of Economic Information. The outlook report of 1928 received the greatest distribution of any single report of the bureau at any time.

The efforts to codify the facts of agriculture into a practical chain of publications have been continued. Daily, weekly, monthly, and annual publications have been arranged more nearly to fit together to make a complete series that is readily understood and used. First steps have been made toward the development of a more complete series of elementary economic circulars bearing upon each farm product.

SERVICE TO THE PRESS

Approximately 300 press releases covering the research and regulatory

work of the bureau were prepared and distributed during the past year. These releases dealt largely with the bureau's activities in farm-management research, cooperative marketing, shipping-point inspection, market news, standardization and grading, and economic research in land economics, farm finance, and rural sociology. They were distributed to farm journals, daily and weekly newspapers, press associations, trade journals, and other publications interested in agricultural economics.

Requests from farmers and educators in agricultural economics indicate that the bureau's press activities have been the means of stimulating the demand for economic information by farmers in the adjustment of farm production to market needs.

There is constant call for information additional to that contained in the bureau's press material, and much time is required to furnish this information to special writers and others who need details. Much assistance has been given to periodicals in the preparation of market columns and pages presenting an official picture of national agricultural market conditions.

Press statements are issued monthly on the current agricultural situation, agricultural prices and indices, the cold-storage holdings of farm products, and on several other of the regular reports of the bureau. These releases have enjoyed an unusually wide popularity and are published regularly by several hundred newspapers throughout the United States. One press association alone distributes the release on the agricultural situation to more than 1,400 publications. Special signed articles are prepared, and a service is maintained whereby publishers and agricultural writers may obtain photographs which illustrate the bureau's work.

RADIO MARKET NEWS SERVICE

The distribution of market news by radio broadcasting has been further developed and strengthened and a better organization of the work effected. There has been a development of contacts with additional stations indirectly through the press associations and commercial news agencies. At Los Angeles a program of market reports was furnished by the Los Angeles branch offices to Station KFI. Improved arrangements with the stations KYW and KDKA have effected new programs of reports at Chicago and

Pittsburgh. A large commercial organization cooperating with the bureau in the distribution of market reports improved the service at Atlanta and Memphis and set up a new program at Kansas City.

New livestock market reporting offices were opened at Buffalo, Cleveland, Indianapolis, Cincinnati, and St. Joseph. Market news broadcasting was greatly improved by the establishment of regular programs at each place. At St. Joseph, Mo., the radio station installed a microphone in our livestock branch office so that prompt release of the market reports could be provided.

The establishment of a bureau of markets in Tennessee increased the interest in market news, and a good program of reports at Nashville resulted. There have been decided improvements in the program at stations at Denver, Minneapolis, St. Louis, and Rochester.

Improved broadcasting from Philadelphia radio stations enabled the Delaware Bureau of Markets to give the growers mail and telephone reports more efficiently.

A special economic program was carried on over the station at Denver in cooperation with the Colorado extension service. Talks by specialists in Washington were telegraphed to Denver for Friday release. This service has met with wide approval in the intermountain country.

A series of 30 economic talks, prepared as our contribution to the radio farm-school program of the department, covered the business of farming, marketing, and cooperative marketing. The 10 lectures under each subject were later printed as circulars.

PERMANENT PUBLICATIONS

The bureau provided a larger share of the annual Yearbook material than last year. The output in the regular department series was about the same as last year—a total of 54 printed bulletins, circulars, and service announcements. Nearly 100 special mimeographed reports, speeches, and articles have been issued. The volume of special articles, reports, etc., has increased somewhat, and the editorial work done for various offices has made a substantial growth. The size of Crops and Markets has grown somewhat, and further expansion is needed to print the growing volume of statistics gathered by the bureau, such as the new cotton staple estimates.

ECONOMICS EXHIBITS

The contribution of the bureau to the exhibits program of the department during the past year has been large. The special display at the World's Poultry Congress, Ottawa, Canada, July, 1927, contained elaborate presentations of the marketing of poultry and eggs. These exhibits have been used extensively since in connection with State and local fairs. At the National Dairy Exposition held at Memphis, Tenn., the bureau provided 5 out of a total of 10 units displayed by the department. At the Chemical Industries Exhibition in New York City the bureau showed an exhibit on the utilization of cottonseed and cottonseed products, including the standards for cotton linters. This exhibit has been asked for by the National Cotton Exhibition at Memphis in 1928. At the Dairy Industries Exhibit in Cleveland, Ohio, the bureau contributed 4 out of the total of 8 units displayed.

At the International Livestock Exposition in Chicago, December, 1927, the bureau contributed 3 units, on the outlook work, the livestock market news, and the beef grades. After the international closed, the outlook booth and a special booth on cooperative marketing of livestock were shown at the Farm Bureau Federation Exposition in Chicago.

In addition to these showings the bureau exhibit material in the general department State fair program formed a considerable part of that program, which includes showing at 60 State fairs and other expositions, served by the department's exhibit service.

The small portfolio type of exhibit has been developed extensively during the year. These portfolios consist of 5, 6, or 7 panels, 16 by 30 inches. The panels carry illustrative material and legends and are found useful to bureau specialists in discussing phases of bureau work with small groups of people

and for display at meetings. They can be easily sent by parcel post. Portfolios have been made up on cooperative marketing, hay inspection, grain inspection, bulk-handling of grain, beef grades, egg standards, marketing potatoes, rural hospitals, rural libraries, etc.

Numerous requests for exhibit material have been received from State colleges, State bureaus of markets, county agents, and cooperative marketing associations, and in every instance some material has been forwarded; portfolios, easel panels, and standard three-panel exhibit booth together with models of dairy farms, chicken houses, and community club houses have been furnished.

MOTION PICTURES AND FILM SLIDES

The program of motion pictures for the bureau during the last year included two pictures, *What's Ahead*, dealing with outlook work, and *Cooperative Marketing of Livestock*. Another picture was practically finished relating to the combine harvesting of grain. One other picture was partly photographed relating to the master farmer movement in Oklahoma. Film slides on several subjects were made, and plans were made for a general use of this method of presentation, which is rapidly replacing the old method of glass lantern slide.

PHOTOGRAPHIC LABORATORY

The use of photography as an aid in the bureau's work is increasing. This process is quick and economical with many types of work. The new rotaprint process has proved to be a time and money saver in reproducing drawings, tables, and other designs quickly in moderate numbers. A new laboratory was equipped during the year, and over 350 rotaprint stencils were turned out. The laboratory has also done a large amount of color work for exhibits, etc., which has included color by oil paints and by water color.



DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., August 30, 1928.

SIR: I have the honor to transmit herewith a report of the operations of the Bureau of Animal Industry for the fiscal year ended June 30, 1928.

Respectfully,

J. R. MOHLER,
Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

ACTIVITIES OF UNUSUAL PROMINENCE

The work of the Bureau of Animal Industry during the year just closed dealt, as heretofore, with experimental projects, research problems, enforcement of Federal livestock laws, control of animal diseases, and varied inspection duties. In this broad field the bureau renders public service of fundamental character, such as finding the answers to unsolved problems, reducing losses from disease, bettering conditions in the transportation and marketing of live-stock, and administering Federal laws and regulations.

The annual period covered by this report was fruitful in many respects. There was material progress in eradicating tuberculosis, cattle ticks, and several other diseases and parasites. Research and experimentation yielded new facts of practical value. In regulatory work there was satisfactory compliance, for the most part, with the statutes administered by the bureau.

The more detailed results of experimental and research work are available to the public in bulletins or in the Journal of Agricultural Research. This report deals chiefly with topics of special interest as well as providing an annual record of the principal lines of bureau work.

ADMINISTRATION OF THE PACKERS AND STOCKYARDS ACT

The year just closed marked the first year of the bureau's administration of the packers and stockyards act. This important activity, which provides for the supervision of the more important public stockyards and the operations of packers and market agencies, embraces a wide range of duties. The year's work in this field included, briefly, the institution of 78 formal dockets involving alleged violations of the act, a study of stockyards rates and charges for services rendered shippers, the investigation of trade practices with special reference to complaints of charges, weighing, and errors in accounting, a survey of the bond situation, a study of scales and weighing, and the auditing and investigation of records of market agencies. Seventy-five stockyards were under supervision at the close of the year.

A large number of complaints, made under the act, were settled informally by the supervisors of the 20 field offices, but formal proceedings were necessary in other instances, most of which were of a more serious character. They involved such offenses as conspiracy to violate the act, false accounts, evidence of boycotting, and refusal of dealers to furnish bonds to cover their obligations on public stock-

yards. Several dockets that had been pending for a number of years were terminated successfully, and the number of all dockets was reduced as the result of the year's operations.

The results of legal proceedings, together with salient facts concerning the general operations of the market agencies under supervision, are given more fully under the operations of the Packers and Stockyards Division.

RECORD VOLUME OF TUBERCULIN TESTING

The campaign against tuberculosis of livestock made unprecedented progress, establishing a new high total for the volume of tuberculin testing. During the fiscal year the total number of cattle tuberculin tested was approximately 11,300,000, which is about 1,600,000 more than during the previous 12 months. The figures are even more significant when it is remembered that tuberculosis eradication is conducted almost entirely at the request of individual livestock owners. During the progress of this work the percentage of reactors has declined, showing the effectiveness of the campaign in eradicating the disease. The average percentage of tuberculous cattle detected by the test in the fiscal year 1928 was 2.4, compared with 2.9 for the preceding year.

Another important development was an increase of 166 counties engaged in the eradication of tuberculosis on an area basis. This number brings the total of counties so engaged to 1,119, or approximately 17 per cent more than the number of areas engaged in the work at the close of the fiscal year 1927.

A survey of municipal milk ordinances revealed that more than 2,100 cities and towns are seriously concerned about the safety of their milk supplies. About three-fourths of that number require the tuberculin test of the cattle furnishing milk; most of the others permit a choice between tuberculin testing and pasteurization.

ACTIVE YEAR IN MEAT INSPECTION

The Federal meat-inspection service experienced an active year, marked by an increase, compared with the previous year, of more than 6 per cent in the number of animals slaughtered under inspection.

On December 1, 1927, B. A. I. Order 305, governing the importation of animal casings, became effective. This order provides for Federal control over a class of products which formerly received no supervision. The fact that

more than 35,000 pounds of such casings offered for importation during the 7-month period of the year were rejected is evidence of the need of this safeguard.

CONTINUED PROGRESS IN TICK ERADICATION

The eradication of cattle ticks from Southern States continues to go forward systematically and is gradually reclaiming more territory from this pest. At the close of the fiscal year the excellent progress of tick eradication in Oklahoma gave promise of early release of that entire State from Federal quarantine.

Following the release last year of South Carolina, the prospect of adding another State to the southern tick-free area is unusually gratifying. The fact that a number of infected premises in Oklahoma will need to remain under supervision for another season only slightly dims the achievement. As in the past, the exact territory subject to Federal quarantine because of the cattle ticks is determined late in the calendar year on the basis of final dipping reports for the season.

SUPERVISION OF BIOLOGICAL PRODUCTS

In the administrative and regulatory work under the virus-serum-toxin act several noteworthy developments occurred during the year. Coupled with a large output of biological products used in combating livestock diseases, their exportation continues to increase. Export shipments reported to the bureau during the year amounted to more than 26,000,000 cubic centimeters, chiefly anti-hog-cholera serum. Since a number of countries do not require official certificates to accompany shipments, the total quantity of biologics exported probably exceeded the figure mentioned. The production of clear anti-hog-cholera serum was, for the first time, greater than that of defibrinated blood serum, indicating a public preference for the clarified product.

Supervision over licensed establishments showed a general compliance with the law and regulations promulgated under it, but there were several notable exceptions, which resulted in the revocation of one license and the suspension of licenses in two other cases. The causes included unsanitary conditions, improper methods, false records, and other irregularities. The requirements of the virus-serum-toxin act and regulations are specific and their strict enforcement

is necessary to insure pure and potent biological products which are so essential in preserving the health of domestic livestock.

FOREIGN MALADIES EXCLUDED

It is gratifying to report the continued freedom of the United States from such serious diseases as foot-and-mouth disease, rinderpest, contagious pleuropneumonia, surra, and European fowl pest. Foot-and-mouth disease is especially feared. A comprehensive report prepared by the United States Department of Agriculture Foot-and-Mouth Disease Commission, which studied the disease in Europe, was printed during the year. This valuable public document summarizes the experiences of European countries in dealing with the malady. The report contains an abundance of scientific data showing the extreme virulence of foot-and-mouth disease and the desirability of continuing to combat it, under conditions prevailing in the United States, by the prompt slaughter of infected or exposed animals. The danger of spreading the disease is especially great in its first stages, which explains the need for prompt diagnosis and the burying or burning of affected carcasses with the least possible delay.

During the year the bureau investigated several reports of lesions similar to those of foot-and-mouth disease, but all of them proved to be the symptoms of other maladies.

INFECTIOUS ABORTION

The loss caused annually by infectious abortion is estimated as twice that of a decade ago. Its financial toll probably exceeds \$50,000,000 a year, including reduced milk flow, loss of calves, and breeding troubles, such as temporary and permanent sterility.

Investigations of infected herds already have shown that advantage may be taken of natural immunity. Artificial means for increasing resistance likewise holds out promise of beneficial results. Two results of considerable importance were brought out by the year's work, namely: (1) Vaccination in calfhood produced sufficient immunity to carry all the animals treated safely through their first pregnancies, even though severely exposed; (2) an abortion vaccine, prepared from a strain of *Bacterium abortus* manifesting little or no virulence, that afforded a marked degree of protection against exposure when given to pregnant animals, proved to

be of little or no value when given before conception. Both of these findings should be of value in developing improved methods of vaccination against bovine infectious abortion. To carry on additional experiments in order to meet the public's demand for further information the bureau is utilizing its present resources to the utmost and has asked for an appropriation that will permit a still more active program of study during the fiscal year beginning July 1, 1929.

ANAPLASMOSIS RECEIVES STUDY

The malignant febrile disease of cattle known as anaplasmosis has continued to receive the bureau's attention. Though occurring chiefly in Southern States, anaplasmosis has been found also as far north as Kansas and as far west as Nevada and California. Contrary to a rather common belief, it has no apparent connection with tick fever except that both maladies have occurred to some extent in the same region.

ANIMAL-PARASITE INVESTIGATIONS

A nation-wide survey of livestock parasites, completed early in the year, showed a distinct need for more research as well as for control measures. The inroads of several animal parasites on which comparatively little scientific work has been done, have been especially serious. To cope with the problem more fully the bureau has outlined a program of research concerning them and also for determining the more practicable control measures. Funds for these important projects fortunately have been made available at a most opportune time.

One line of investigation that gives promise of early practical benefits includes studies of parasites, worm eggs, and larvae in manure piles. Thus far, little is definitely known concerning the effect of manure spread on fields and pastures that are grazed by livestock. Recent experiments have indicated that the heat in manure piles and pits kills eggs and larvae near the center of the manure. On the outside of the manure mass, however, eggs and larvae survive. The question of making manure safe for use on pastures is receiving further study.

B. W. D. PROJECT ORGANIZED

Several conferences dealing with bacillary white diarrhea resulted in the organization of a comprehensive project for the study of this serious

poultry disease. The investigators who are conducting the work were selected with special reference to their training and experience in the various sciences, poultry breeding, and other phases of the problem. The plan of procedure includes studies to determine the danger, if any, of hatching infected and noninfected eggs in the same incubator, to study methods of diagnosis in adult fowls, to determine the best methods of disinfection, the period of incubation of the disease, and methods of prevention by vaccine. The work is now in progress.

ANIMAL-HUSBANDRY INVESTIGATIONS

Investigations in animal husbandry have continued to include the study of basic problems in breeding, feeding, and management of domestic livestock. In addition, meat, wool, mohair, and other animal products have been the subject of additional research.

Most investigations continued in cooperation with 20 State experiment stations and other agencies are yielding facts concerning many questions hitherto unanswered. Tenderness in beef apparently depends on several factors, including the character and quantity of connective tissue, length of fibers, and their arrangement. Dark color in meat, however, does not seem to be definitely related to tenderness or palatability.

Other studies have shown that in the case of lamb fat variations of firmness are due more to the degree of fatness of the animals than to the composition of the fat itself. The investigations continue to show the complexity of meat problems, and the results of individual experiments serve more as a basis for progress reports than for final conclusions.

In beef-cattle investigations the feeding of a supplemental grain ration to fattening steers on grass has not only increased the gains on steers over those made by steers on grass alone, but the profits per steer and the quality of beef have been increased considerably. In a three-year experiment conducted in West Virginia steers getting grain in addition to grass sold from \$1.25 to \$1.40 more per hundred-weight than similar steers getting grass only.

The results of nutrition studies with hogs at several of the bureau's farms tend to show the economy of finishing market hogs at young ages. Since market demands are more consistently for lighter-weight hogs than formerly, the selection of proper type for early

development is of greater importance than in previous years.

The bureau's efforts to maintain and improve its stud of Morgan horses at Middlebury, Vt., have been successful, as indicated by increases in height and weight and the development of stamina and other good qualities. Morgans bred and developed by the bureau performed well in recent endurance rides and likewise have won prizes at various expositions. Breeding stock has been sent to many States and foreign countries. Thus the breed not only has been saved from extinction, but the blood lines are being improved.

Poultry-industry leaders were active during the year in making plans for better control of diseases, improvement of average egg yields, and reduction of chick mortality. The business of commercial hatcheries especially has become more and more interstate in character, and there has developed a need for some form of official supervision with respect to control of diseases and the quality of chicks distributed. The bureau has cooperated with the various States and other agencies interested in the development of such supervision.

LIVESTOCK IMPROVEMENT

As in former years, the bureau continued to lay stress on the importance of breeding improved types of domestic animals owing to their greater utility value over inferior livestock. In this work primary reliance has been placed on the use of purebred sires. The number of livestock owners participating in the systematic campaign for the use of purebred sires in all classes of livestock raised continued to increase, the total number of such users enrolled at the end of the year being 17,254.

Interest was especially marked in two more counties which, emulating the previous achievement of Union County, Ky., succeeded in eradicating all grade and scrub bulls. These new areas were Craig County, Va., and Russell County, Ky., in both of which the result was achieved largely under the leadership of energetic county agents and State extension workers.

The results of a world survey on livestock improvement, mentioned briefly in last year's report, showed that the principal livestock countries of the globe are also relying on the extensive use of selected purebred sires to raise the average quality of domestic animals.

PERSONNEL

Changes in personnel during the year affected the administration of four major lines of bureau work. The untimely deaths of J. A. Kierman, chief of the Tuberculosis Eradication Division, and of E. C. Schroeder, superintendent of the experiment station at Bethesda, resulted in the selection of A. E. Wight and W. E. Cotton, respectively, to fill these important places. The resignation of John T. Caine, who was in charge of the Packers and Stockyards Division, resulted in the assignment of A. W. Miller to take charge of that work. Doctor Miller, who had been chief of the Field Inspection Division, was succeeded by G. W. Pope.

The bureau rolls at the beginning of the fiscal year carried the names of 4,071 employees located in Washington and at various field stations. Additions during the year numbered 788, made up of 597 new appointments, 32 reinstatements, 9 transfers from other bureaus or departments, and the assignment on July 1, 1927, of the 150 employees of the Packers and Stockyards Administration as a division of this bureau. Separations from the service aggregated 688, of which number 172 resigned, 29 died, 30 were transferred to other bureaus, or departments, 75 were retired, and 1 was removed for cause. Other separations numbered 381, largely unclassified employees, such as agents, unskilled laborers, and other seasonal and temporary employees.

On June 30, 1928, the bureau rolls contained the names of 4,171 employees, an apparent increase of 100, but an actual decrease of 50 in the bureau force as it existed before the taking over of the Packers and Stockyards Administration.

VETERINARY EDUCATION

A survey of the operations of accredited veterinary colleges shows a gratifying increase in attendance along all lines. The number of registered freshmen in the accredited colleges in the United States and the one in Canada was 242 for the college year 1927-28, as compared with 193 during the previous year. The number of graduates was 136, an increase of 21 over the number in 1926-27. The number of accredited veterinary colleges was 12, the same number as the year before, and the 10 foreign recognized institutions also remained the same. The increased student reg-

istration and number of graduates seem to presage a growing recognition of the veterinary profession as a promising career for young men.

The Bureau of Animal Industry requires approximately 100 well-trained young veterinarians annually in order to maintain its inspection force at proper numbers for performing essential work. Veterinarians in the bureau's service number about 1,300, which is by far the largest single group of trained veterinarians in the country.

For several years in the past a declining attendance at veterinary colleges was attributed by those in charge to low salaries paid veterinarians in the Federal service. It was believed that the bureau's scale of salaries was a potent influence in fixing general salaries because of the large number of graduates it employs.

During the last fiscal year both the Bureau of the Budget and Congress gave sympathetic consideration to the need for higher salaries for veterinarians, more nearly on a level with salaries paid other scientific workers in the department. Hearings on this question resulted in the inclusion of \$199,680 in the appropriation act to be devoted exclusively to promotions of field veterinarians in the Bureau of Animal Industry. This fund has made possible an average increase of \$153 for each veterinary employee, though it does not entirely wipe out the discrepancy between the salaries of veterinarians and those of other scientific workers in the department. The increased interest in veterinary education, coupled with higher salaries now being paid by the bureau, marks a significant trend for the better in the veterinary situation.

LITERATURE, EXHIBITS, AND MOTION PICTURES

Publications prepared by the bureau during the year included 151 new and revised documents, a material increase over the previous year. Contributions to the various series of publications included 62 farmers' bulletins, 9 technical bulletins, 5 department bulletins, 3 department leaflets, 2 department circulars, 7 contributions to the Journal of Agricultural Research, 6 orders of regulatory character, 40 yearbook papers, 4 publications of miscellaneous nature, and 13 Service and Regulatory Announcements, including an index.

As in the past, there was furnished to the press service of the department timely articles to the number of approximately 125 dealing with results

of research work, the discussion of regulations, and other topics suitable for distribution to the press. The bureau also contributed a large volume of material to the radio office for broadcasting purposes.

In cooperation with the office of exhibits of the department, specialists of the bureau furnished the subject-matter material for the preparation of 12 new exhibits and the revision of 3 former ones for showing at State, interstate, and international fairs and expositions. Exhibits were shown at 26 major fairs during a total of 186 exhibition days. These events were held in 20 States and the exhibits were seen, it is estimated, by more than 2,000,000 people. In addition, exhibit material was furnished for 49 miscellaneous occasions, including 5 livestock trains. Six small displays were also prepared in response to requests.

The bureau has continued to cooperate with the department's office of motion pictures in preparing scenarios and in directing photography with respect to subject matter. This activity resulted in the completion during the year of four new films dealing, respectively, with hog-cholera control, fowl tuberculosis, beef-cattle improvement, and livestock sanitation.

The year's work as conducted by the various divisions is presented more fully in the following pages.

ANIMAL HUSBANDRY DIVISION

The work of the Animal Husbandry Division, consisting chiefly of research in animal husbandry, including poultry husbandry, was conducted under the direction of E. W. Sheets, chief.

ANIMAL GENETICS

The inbreeding program with five distinct families of guinea pigs was continued, and during the year some of the families reached the twenty-ninth generation of brother-sister mating. A summary of the results obtained during the period 1906 to 1924 has been prepared for publication. It was shown that after nine years of exclusive brother-sister mating the five families had fallen below the average of the control stock in weight, fecundity, and vitality of young, as well as having become markedly differentiated from one another in these respects. During the second nine years of inbreeding there was no further decline of the inbred stock as a group relative to the control stock.

With respect to weight, each strain differed from every other strain in average, and in no case was there a significant difference in trend. With respect to other characters there were, however, some significant differences in trend. The results are in general accord with the Mendelian theory of inbreeding.

In the swine-inbreeding experiment there have been farrowed a total of 403 first-generation, 243 second-generation, and 39 third-generation pigs from brother-sister matings. In general, there has been a decline in vitality of the pigs farrowed, number raised, and rapidity of gains. In particular cases such a decline has not occurred, second-generation pigs having been produced which were the equal of outbred stock.

ANIMAL NUTRITION

In connection with soft-pork investigations, approximately 3,150 lard samples from 1,425 hogs have been examined, and the thickness of the back fat of more than 1,000 hogs and the water content of the back fat of 370 hogs have been determined. The refractive index has been determined on the fat from 178 sets of beef ribs, 590 lambs, and 26 chickens. Determinations were made of the relative amounts of the various fatty acids in the lard of hogs fed corn and soy beans in definite proportions in dry lot as compared with hogs permitted to hog down corn and soy beans. When the results are compared on the two lots of hogs an estimate can be made of the proportion of these feeds consumed in hogging down.

It was found that variations in the firmness of lamb fat seem to be due to the degree of fatness of the lambs rather than to the composition of the fat.

Analyses were made of the following: (1) The separated fat and lean of 150 beef ribs; (2) the commercial cuts of 6 beef carcasses, 1 lamb, and 3 hogs; (3) 14 loins of lamb; and (4) the breast, leg, and remaining edible portions of 32 chickens. This work represents approximately 6,000 analyses. The carcasses of 4 reindeer were prepared for analysis.

Studies have been begun in cooperation with Johns Hopkins University and the United States Egg Society on the relation of feeds to the fattening ability of cockerels, the composition of the meat of unfattened and fattened cockerels, and the composition of the bones of such birds. The first year's results indicate the

desirability of simpler rations than are now in vogue. The best protein level for growing chicks appears to be about 20 per cent of the ration.

COOPERATIVE EXTENSION

Results obtained in animal-husbandry extension work show a marked growth over the preceding year—in fact there has been a gradual increase in total number of recommended practices adopted by livestock farmers since 1924.

As in the past, the Animal Husbandry Division has cooperated with Federal and State extension workers in the establishment and continuance of projects dealing with fundamental livestock problems. Among noteworthy developments were an increase in the number of farms using purebred sires, an increase in the number of stock owners who fed better-balanced rations, and also increased numbers of boys and girls engaged in livestock-club work. Other livestock extension work centered about the culling of sires, improvement of pastures, raising home-grown feed, and improvement in livestock sanitation.

In the range areas extension work with sheep dealt with better range management and the culling of ewes on the basis of fleece. In the farm States the work included supplemental feeding of breeding flocks and lambs, docking and castrating, control of internal parasites, and early marketing of lambs.

Various recommendations were incorporated in the requirements dealing with "ton litters" and "pig crop" contests carried on in the majority of States. Official ton litters produced numbered 752. Interest in "pig crops" increased during the year, the purpose being to produce the greatest quantity of pork per sow in a specified time, taking into account also the most desirable market size of the pigs.

In the case of work stock the principal lines of extension included multiple-hitch demonstrations, horse and mule pulling contests, and colt, stallion, and gelding clubs.

In poultry extension work the culling of low-producing hens has changed from a demonstration project to a commercial practice. County, regional, and state-wide culling schools are replacing the farm-culling demonstrations. Persons who prove their efficiency in the art of culling are often employed by hatchery operators, feed dealers, and poultry-improvement associations. Service is thus provided

for individual farmers. Extension work with poultry has dealt also with better sanitation under the slogan "Grow healthy chickens."

MEAT INVESTIGATIONS

During the year 20 State experiment stations, the Institute of American Meat Packers, the National Live Stock and Meat Board, and three bureaus of the department cooperated in the national cooperative project entitled "A study of the factors which influence the quality and palatability of meat."

A total of 850 head of experimental cattle were fed in accordance with the standard plan of work agreed to by the cooperators. Of these, 97 cattle were shipped to the bureau's meat laboratory at Beltsville, Md., for detailed study. The others were marketed at local points, 292 representative rib cuts being taken from the carcasses and sent to Beltsville for analysis and comparison. A total of 706 lambs were fed out in accordance with the project plans, all being shipped to Beltsville. The carcasses of 541 were given a detailed study. A total of 1,224 hogs were also slaughtered and handled through the laboratory.

Sales of surplus meat for the year were: Government-owned products, \$10,217.35; sales of cooperating State experiment station products, \$29,674.10; total sales, \$39,891.45.

Records of 522 hogs cut according to the standard method have been classified by weight and sex. On the basis of carcass weight, these figures show a higher yield of ham, loin, rib, head, and feet in the light-weight hogs. These are the parts that normally contain the greatest quantity of natural muscle and bone. The heavier and fatter hog carcasses excelled only in yield of bacon and fat.

Of special interest is the fact that the sows cut out a higher proportion of ham and loin and a lower yield of fat and bacon than the barrows. Curing yields from this meat also show a consistent difference in yield.

The mechanical device developed for measuring the power required to shear both raw and cooked fibers of meat continues to give consistent results for both the right and left sides of the same animal. It also segregates some highs and some lows from a group. For instance, a lot of beef ribs averaging from 60 to 70 pounds shearing strength may include some, the rights and lefts of which both run up to 85

or 90 pounds, while the meat from another animal may be as low as 45 or 50 pounds.

Cutting, handling, and sampling for the mechanical test for tenderness provided an opportunity to study the marked contrasts in the mechanical condition of the samples. Differences have been striking both between entire consignments from separate experiment stations and between individual samples in the same lot.

Separation of the wholesale cuts of beef from experimental carcasses into lean, bone, and fat has been followed with the chemical analysis of each sample. In the prescribed portions of the rib cut the lean has been further divided into "eye" muscle and other lean. This has been done to correlate the amount of "eye" with other factors and to determine chemically the relation of visible marbling to the actual fat content of the tissue. Amount and character of connective tissue, length of fiber, and arrangement of fiber all seem to affect the texture of the meat and have an influence upon its tenderness. However, it appears that there are other factors as yet but partially identified which have a bearing on the grain and actual tenderness of the meat.

There has appeared to be no definite relation between dark color in meat and lack of tenderness and palatability. Most of the plain meat tends to be dark, but dark meat with other marks of quality has not consistently differed from the tenderness and palatability of bright meat.

BEEF-CATTLE INVESTIGATIONS

Research in beef production has been conducted during the year in the Appalachian region, the Corn Belt, the Cotton Belt, the Sugar Cane belt, and the southwest and northwest range areas.

FATTENING STEERS ON GRASS IN THE APPALACHIAN REGION

A cooperative project with the West Virginia Agricultural Experiment Station, conducted at Lewisburg, W. Va., to compare the effect of grain as a supplement to grass in the fattening of steers, and also the effect on the quality of meat produced, has been completed. An average daily grain ration per head of 6.7 pounds of corn and 1.83 pounds of meal for 121 days produced a total gain of 327 pounds per head, which was approximately 60 pounds more than the gain of the steers getting grass alone. The addition of a

grain supplement increased the selling price \$1.30 per hundredweight and improved the quality of the meat noticeably.

A cooperative experiment with the Virginia Agricultural Experiment Station at Blacksburg, comparing the finishing of steers on grass alone, on grass and grain supplement, and on a short, dry-lot finish immediately following the grazing season showed an advantage in feeding the steers on grain for a short period in the dry lot. During the previous year the grain-and-grass lot made the greatest net returns. During the first year's test the pastures were better than for the last year, which indicates that under favorable grazing conditions it is desirable to feed a supplement on grass and market early in the fall, and when pastures are inferior a dry-lot finish may be desirable.

METHODS OF HANDLING CALVES PREVIOUS TO WEANING

A third year's test in a cooperative experiment with the University of Missouri, comparing various methods of handling beef calves prior to weaning, is being completed at Sni-a-Bar Farms, Grain Valley, Mo. The year's work shows that calves fed grain previous to weaning returned an average of \$9.50 more per head than calves allowed to run with their dams on pasture without grain. The lot of calves kept on pasture separate from their dams but allowed to nurse twice daily made greater returns during the last year. The first year's work showed a decided advantage for the calves fed grain and allowed to run with dams on the same pasture. In the second year there was practically no difference between the lots getting a supplement of grain. The 3-year experiment shows conclusively that it is profitable to feed calves a grain mixture while they are running on grass prior to weaning, and that calves may either run with their dams or be kept in separate pastures satisfactorily. More labor, however, is involved in the method of allowing separate pastures for cows and calves and permitting calves to nurse twice daily.

WINTERING AND FATTENING BEEF CATTLE IN THE RANGE COUNTRY

At the Ardmore Field Station, Ardmore, S. Dak., four lots of 10 head each of yearling steers averaging 655 pounds on November 11, 1927, were wintered on various roughages. A ration of 10 pounds of straw and 5

pounds of alfalfa produced a gain of 40 pounds per head during a six-month period. Alfalfa hay at the rate of 15 pounds per head per day produced a gain of 70 pounds for the same period, while a like amount of wheat-grass hay produced a gain of 83 pounds. A ration of 20 pounds of silage and 5 pounds of alfalfa produced 148 pounds gain. The results of the year's test coincide with previous work at the station, showing that native wheat-grass hay is fully as valuable in wintering steers as alfalfa hay. The relative prices of each should determine which one to use in the ration. The ration of 10 pounds of oat straw and 5 of alfalfa, while not producing as great gains as 20 pounds of silage and 5 pounds of alfalfa, was nevertheless a satisfactory ration and considerably cheaper. The data show that a gain of 40 pounds, as made by the stover and hay ration, is satisfactory for a winter gain of yearling steers. The experiment shows also that at the end of the following grazing season the steer gaining 40 pounds during the preceding winter will be as heavy as the one gaining much more and the cost will be much lower.

At the United States Range Livestock Experiment Station, Miles City, Mont., an experiment to compare alfalfa and bluejoint hay for wintering yearling heifers showed that a daily ration of 23 pounds of alfalfa hay for 84 days produced 51 pounds of gain, while 19½ pounds of bluejoint hay for the same time produced 65 pounds of gain. The bluejoint hay was not only superior to the alfalfa in gains produced, but also cost less per head for wintering. Similar results were obtained last year.

An experiment comparing several rations for wintering calves showed that alfalfa hay alone produced practically as satisfactory results as when it was supplemented with cottonseed cake and corn silage. Similar results were also obtained during the previous winter. This is important because of the availability of alfalfa hay, the uncertainty of corn production, and the trouble of shipping in cottonseed cake.

An experiment in which four lots of steers were fattened on varying amounts of barley and alfalfa hay, with and without cottonseed cake, showed that a full feed of barley produces greater gains than a half feed with alfalfa, at a cost of about \$1 more per 100 pounds. On a half feed of barley about 33 per cent less barley, but twice as much hay, was required to produce 100 pounds of gain. The

full-fed steers sold for 40 cents per 100 pounds more than the half-fed barley steers. Cottonseed meal at the rate of 1 pound per head per day added to a full feed of barley and alfalfa increased the daily gain slightly, but not to such an extent as to more than offset the additional cost, as sale prices per 100 pounds and profits per head were very similar in all lots. The results indicate that when barley is plentiful it is desirable in the case of fattening steers to feed a maximum amount and supply protein entirely in the form of alfalfa hay, if available.

Investigations carried on cooperatively with the Montana Agricultural Experiment Station at the North Montana substation at Havre, consisted in the wintering of beef cows and heifers and the fattening of calves. The following roughages were each fed separately to groups of 10 head of Hereford cows: Oat hay, alfalfa hay, sweet-clover hay, corn fodder, and bluejoint hay. The test showed that from 17.5 to 19 pounds of hay made from oats, alfalfa, sweet clover, or bluejoint is equal to from 30 to 35 pounds of corn fodder in wintering rations for breeding cows.

At the same station two lots of 10 head of heifer calves were wintered respectively on alfalfa hay and alfalfa hay with straw in addition. In a wintering period of 154 days a daily ration of approximately 14 pounds of alfalfa hay per head produced practically the same gain (185 pounds per head) as the same quantity of hay with 6 pounds of straw in addition. When there is a shortage of hay, however, it would be advisable to feed less of it and whatever straw the cattle will eat.

Three lots of calves, 10 head per lot, were fattened at the North Montana substation on the following rations: Barley, oats, and alfalfa hay; rye, oats, and alfalfa hay; and barley, oats, and chopped alfalfa hay. In each of the three lots one-quarter of the grain fed was oats. Indications are that barley is a more satisfactory feed for fattening calves than rye when fed in conjunction with oats and alfalfa hay. Chopping of the hay increased the gains slightly, but not sufficiently to warrant the additional labor cost.

LIVESTOCK PRODUCTION IN THE NORTH-ERN GREAT PLAINS

A study of 60 ranches in the northern Great Plains showed that even with recent favorable cattle prices

some ranches are not being operated at a profit, owing to poor organization or operation, or both. The calf crop, always one of the important factors in the beef-producing business, varied widely on these ranches in 1927 and averaged only 65 per cent for all of them. Some ranches were being operated to produce calves and yearlings when the grazing and feed resources suggested 3-year-old steers as the most profitable product. Winter-feed requirements furnish the most pressing problem in this area, as on most ranches not enough hay can be put up for all the cattle that can be grazed. Various crops, such as spring grains, have to be sown to supplement the supply of native hay, alfalfa, and sweet clover. This limited supply of roughages and almost unlimited grazing is the cause of the trend back to the production of aged steers.

BEEF-PRODUCTION STUDIES IN THE SOUTH

A three-year experiment at the State Agricultural and Mechanical College, Jonesboro, Ark., in cooperation with the Arkansas Agricultural Experiment Station, to compare the progeny of purebred, grade, and native cattle has just been completed. There were no significant differences in their progeny in the following particulars: Birth weights, daily gains to weaning age, and feed required per 100 pounds gain for fattening from weaning age to 1 year old. On the other hand, the better-bred calves surpassed the lower grades in the following particulars: Daily gains during the fattening period, dressing percentage, and sale price, the purebred calves, bringing from \$1.25 to \$1.75 per 100 pounds more than the scrub calves.

In an experiment at the Iberia Livestock Experiment Farm, Jeanerette, La., comparing Brahman-Hereford crosses, it was found that one-fourth Brahman-three-fourths Hereford steers made a better showing in the feed lot than one-half Brahman-one-half Hereford steers.

PUREBRED HERD DEVELOPMENT

Milking Shorthorn and beef Shorthorn herds are being developed at the United States Morgan Horse Farm, Middlebury, Vt., and the United States Animal Husbandry Experiment Farm, Beltsville, Md., respectively. Experimental work has been confined to production costs only, because of the small numbers of cattle.

SHEEP AND GOAT INVESTIGATIONS

The problems of the sheep and goat industries have received the attention of bureau research workers in 21 Federal and State experiment stations in various regions of the country. This program includes farm-sheep investigations, range-sheep investigations, studies in wool and other animal fibers, and milk-goat investigations.

FARM-SHEEP INVESTIGATIONS

The study of pastures for sheep includes: Forage-crop experiments at Beltsville, Md.; a comparison of various methods of using pastures in lamb production, in cooperation with Purdue University Experiment Station at La Fayette, Ind.; comparisons of various pastures, both native range and cultivated crops, at the Belle Fourche Experiment Station, Newell, S. Dak.; comparisons of pasture only and pasture with grain for lamb production, in cooperation with the Mississippi Agricultural Experiment station at Agricultural College, Miss. The results of this work indicate the possibility of important economies in sheep production by the liberal use of high-quality pastures. Carcasses of lambs raised on good pasture without grain have proved to be approximately as high in finish and quality as the carcasses from the same kind of lambs raised on pasture supplemented with a liberal feeding of grain. Gains on the lambs on pasture without grain supplements have been satisfactory where the pastures were luxuriant, palatable, and nutritious, and where the lambs have been treated successfully for the control of stomach worms.

At Beltsville, Md., and Middlebury, Vt., experiments in the flushing of breeding ewes were continued, in which studies were made of the effects of extra feeding of ewes at breeding time on their production of twin lambs. The flocks at Beltsville this year showed no significant influence from the extra feed given at breeding time. On the other hand, the flushed ewes at Middlebury had 20 lambs per 100 ewes more than the unflushed ewes, which is only slightly less than the average advantage resulting from this practice for all lambings that have occurred in these experiments during the last 12 years.

In cooperative western lamb-feeding experiments at the Purdue University Experiment Station, La Fayette, Ind., oats were found to compare especially well with corn for fattening lambs as

shown by gains in the feed lot and the quality of the meat.

The bureau's studies in the problems of farm-sheep breeding are concentrated largely at Beltsville, Md., and Middlebury, Vt. At Beltsville this work consists of type fixing of purebred Southdown, Shropshire, Hampshire, and Corriedale sheep. It is a rather general practice among breeders to conform to fancy breed points and show-ring standards. In doing this it is not unusual for them to lose sight of the economic factors in sheep production and breed for characteristics that are detrimental to a breed, as, for example, face covering to the point of wool blindness, and extreme density at the sacrifice of satisfactory length of staple and net weight of clean wool.

Since types of farm sheep are continually undergoing changes it is pertinent that some institutions having in view only the ultimate good of breeds and breeders should make detailed studies of the types best fitted to this country and select and fix those types in flocks under their control. With this purpose in view the bureau has developed breeding flocks of some of the most popular breeds and by a system of detailed scoring has been able to record and tabulate results of breeding more closely than would be possible for very many other breeders. In the conduct of this breeding work no ewe stock is added from outside sources after the foundation is complete. Outside rams are obtained only when there is assurance that some correction or improvement will result from their use as sires.

At Middlebury the improvement of grade sheep was continued by the use of purebred Southdown and Shropshire rams on grade ewes. Second-cross, third-cross, and fourth-cross Southdown and Shropshire ewes were mated to rams of their respective breeds. From the standpoint of commercial lamb and wool production it appears that third-cross ewes are approximately as useful and satisfactory in type as the fourth-cross thus far produced.

RANGE-SHEEP INVESTIGATIONS

On the western ranges of the United States the problems of sheep production are so different from those of farming regions of the Eastern and middle-Western States that a separate series of investigations are in progress for service to range-sheep producers. These investigations are

being continued at the United States Sheep Experiment Station, Dubois, Idaho; the United States Range Livestock Experiment Station, Miles City, Mont.; and Texas substation No. 14, near Sonora, Tex.

At Dubois a study of the use of ranges typical of the intermountain region shows that protection to the range from extremely early grazing results in a greater carrying capacity for sheep than can be obtained from similar range grazed as soon as the vegetation begins to grow. A comparison, during the year, of two pastures of 80 acres each showed that the one protected from grazing in the spring and fully grazed in the fall furnished about 87 per cent more sheep grazing than the pasture grazed heavily in the spring and again in the fall. These two pastures have been handled this way for five years. The pasture protected in the spring is building up, while the unprotected, overgrazed pasture is wearing out.

An analysis of seven years' results in efforts to produce winter feed for sheep on high ranges at an altitude of 5,500 to 6,000 feet proved that it was an uneconomical practice and that land in that locality had better be left unplowed and used for grazing unless water is available for irrigation. The crops tested were sunflowers for silage, peas and oats for hay, sweet clover for hay, and oats for hay. In an occasional year there was rainfall enough to make their production profitable, but the average year was too dry. The sweet-clover crop gave best results but yielded an average of less than half a ton per acre.

Under the conditions of the high, lush, forest ranges in the region of Dubois the tendencies of the Corriedale and Columbia lambs to finish at weaning time make them well adapted to that kind of range for lamb production.

The lamb-production experiment at Dubois, involving the comparison of lambs sired by Hampshire rams and from ewes of the Rambouillet and Corriedale breeds with lambs that are straight Rambouillets or Corriedales, was continued. The results show that Hampshire-sired lambs weighed the most at weaning time, but many of the crossbred lambs which did not finish on the range were too heavy for the most profitable feeding in the Corn Belt. A fairly large percentage of the Corriedale lambs finished on the range, and many of those that did not made good feeder lambs, not being so much overweight as the Hampshire-sired

lambs. The purebred Rambouillet lambs have not finished well enough at weaning time to be acceptable for slaughter except in rare cases, but a large portion of them have made fair feeder lambs.

At Miles City, Mont., a feeding experiment was conducted with high-grade Rambouillet lambs to determine the value of corn silage as an addition to a ration of alfalfa hay and mill screenings. The corn silage was found to increase the efficiency of the ration about 15 per cent and the number of good and choice lambs 18 per cent.

At the Texas substation No. 14, near Sonora, Tex., the cooperative project in the comparison of Corriedale and Rambouillet sheep under the conditions of southern Texas showed that the Rambouillets have the heaviest bodies and unscoured fleeces and that the Corriedales have the largest lambing percentages.

The next question for this project to settle concerns the comparative value of the lambs from these two breeds. Texas sheep growers are wise in not changing from fine-wool production as long as there is no substantial proof that it would improve their situation.

STUDIES IN WOOL AND OTHER ANIMAL FIBERS

The study of factors which influence wool production of range Rambouillet sheep was brought to the stage of publication as Technical Bulletin 85. The greatest influence which the age of the sheep had on wool production was found to be in length of staple, which became shorter as the sheep grew older. After the third year of age this was reflected in the declining fleece weights. The fleeces having the longest staple averaged the heaviest weights of clean wool. The finest fleeces had a tendency to be more dense and of a little higher character (distinct in crimp, bright, and lustrous), but of lighter weight, both unscoured and scoured. While density was somewhat associated with greater fleece weights it was not such an important influence in creating heavier fleece weights of clean wool as was length of staple. Freedom from heavy face covering or wool blindness was slightly associated with greater fleece weights. Skin folds were only slightly associated with heavier fleeces but they were less desirable in character and length. The results also show that desirable mutton conformation as found in these range Rambouillet sheep had some advantages and substan-

tially no disadvantages in efficient wool production. The ewes having heavy fleeces in one year were found to be fairly consistent in the production of heavy fleeces in other years. This consistency in production also applied to length of staple.

Investigations at Beltsville, Md., of the content of clean wool, grease, and dirt have been pursued by improved methods having increased accuracy and greater freedom from laboratory fire hazards. Carbon tetrachloride is being used for grease determinations and this eliminates to a considerable extent the dangers from fire which existed with the previous method of using gasoline for this purpose.

Studies in the growth of wool have been conducted in 12 different parts of the country. The data show that wool does not grow at the same rate in all periods of the year, and work is now under way to determine the influences of these variations. Similar investigations with mohair are in progress in cooperation with the Texas Experiment Station.

MILK-GOAT INVESTIGATIONS

For nearly two decades the bureau has been breeding milk goats. These animals are being used in the study of husbandry problems pertaining to milk goats, with special reference to breeding, feeding, milk production, studies in the growth of kids, and methods of goat management. Results from this work have been published in Farmers' Bulletin 920, Milk Goats.

The bureau's milk goats are all maintained at the Beltsville farm. Forty breeding does are now in the herd, about half of which are Saanens and the other half Toggenburgs. Some attempts have been made to study the value of the milk as a food for infants and invalids by cooperation with attending physicians. It was found that the nature of such a milk study requires highly controlled technical investigations in order that dependable results may be arrived at.

A milk technologist was assigned during the year to the study of goat's milk, using this herd as the primary source. A survey made of the English, German, and French literature on the subject indicates that experimental evidence on goat's milk as a substitute for mother's milk is surprisingly meager. Preliminary feeding observations comparing goat, Holstein, and Jersey milk are being made.

SWINE INVESTIGATIONS

Investigations in hog production were continued during the year at the United States Animal Husbandry Experiment Farm at Beltsville and at the several field stations in the Southwest and Northwest.

At Beltsville 12 sows and their litters are being used in a study of the effect of the diet on the skeletal development of swine, in cooperation with Johns Hopkins University and the American Dental Association. In the first series of tests the lot receiving a ration low in calcium but high in phosphorus showed a pronounced development of rachitis. Similarly, the lot receiving a ration low in phosphorus but high in calcium content showed a slight evidence of rachitis of slow development, as compared with the third or control lot of pigs fed normal rations.

Pigs of spring 1927 litters were used in an experiment to determine the quality of pork produced by hogging down corn with different varieties of soy beans, beginning at approximate average weights of 100 and 130 pounds per pig. Hahto, Manchu, Wilson, and Virginia soy beans were hogged down with corn, and minerals were self-fed in all cases.

As a check against these lots, eight lots of hogs were fed corn and soy beans in dry lot. Four lots with approximate initial weights of 100 pounds received a single variety of soy beans and corn in self-feeders, free choice; and four lots averaging 130 pounds were fed similarly. The same four varieties of soy beans were used as in the hogging-down work, and likewise the same minerals were self-fed.

The results given below were obtained in an experiment to determine the hereditary effect of hardening or softening feeds, eaten by the sow from the time she was weaned until her pigs were farrowed, upon the quality of pork produced by her offspring when fattened on corn and tankage self-fed. Fifteen pigs from sows which had been fed continuously on peanuts were started at an average initial weight of 34.3 pounds and made an average daily gain of 0.939 pound when finishing at average final weights of 205 pounds. Eleven pigs from sows which had been fed brewers' rice started with an average initial weight of 32.1 pounds and made average daily gains of 1.02 pounds when finishing at a final weight of 206.8 pounds. The average feed con-

sumption of pigs from the peanut-fed sows was 4.16 per pound of gain and 4.43 pounds per pound of gain for the pigs in the brewers' rice lot.

More detailed results of these and similar experiments are made public from time to time by the committee in charge of the cooperative soft-pork investigations.

In the fall of 1927 there were 36 pigs at the Iberia Livestock Experiment Farm remaining from the 38 pigs treated as suckling pigs the spring before. These were subjected to virus inoculations without any reactions and showed, therefore, satisfactory immunity.

Immunity tests were conducted with several hogs from the Beltsville herd, which had been immunized as suckling pigs and discarded as breeding animals, with the following results: Three pigs farrowed in the spring of 1923; 1 farrowed in the fall of 1925; 1 farrowed in the spring of 1926; 1 farrowed in the fall of 1927; 3 unvaccinated pigs from fall litters of 1927 and 1 unvaccinated pig from a 1926 spring litter were treated with virus alone.

The 3 spring 1923 pigs, 1 spring 1926 pig, 1 spring 1927 pig, and 1 fall 1927 pig remained well. The pig farrowed in the fall of 1925 developed high temperatures following inoculation and was killed. Post-mortem examination indicated the presence of hog-cholera lesions. The unvaccinated pigs were used as check pigs in these tests and showed the virus to be highly potent.

FIELD STATIONS

The work at the several field stations is representative of conditions of the arid and irrigated sections of the plains country of the Northwest, the coastal plain, and sugar-cane areas of the South.

At the United States Range Livestock Experiment Station, Miles City, Mont., two main projects in swine production were conducted. One relates to the production of hogs that will furnish carcasses suitable for cutting Wiltshire sides that will conform to the requirements of the English market. The other studies the comparative value of sows and gilts for the production of market hogs.

In the first project 17 purebred Yorkshire sows and 17 purebred Chester White sows are being used. Pure breeding and crossbreeding are practiced in the determination of carcasses suitable for Wiltshire side production. A total of 168 pigs was used

in a feeding period of 105 days in which the average weight at the start of the experiment was 40.2 pounds. An average daily gain of 1.3 pounds was made, and they finished at a final weight of 176.2 pounds. The total feed consumption was 3.6 pounds of grain for each pound of gain. In the grading 39 per cent of the carcasses were selected as suitable for the production of Wiltshire sides according to the standards required by the English market.

At the Coastal Plain Experiment Station, McNeill, Miss., 15 purebred Tamworth sows are maintained for production studies. The spring pigs were used to determine the value of a new variety of field peas known as the Six Weeks pea, which had been developed at the Poplarville substation of the Mississippi experiment station, with results that indicate that they will make a desirable feed for hogs. The pigs were fed in five different lots. At the conclusion of the feeding period the pigs were shipped to Beltsville for slaughter and grading.

The fall pigs at the McNeill station were used in tests to determine the relative value of native carpet grass and oat pasture as forage for hogs. Lot 1, of 12 pigs fed a limited ration for four weeks of corn, tankage, and mineral, followed by a full feed for two weeks on carpet-grass pasture, beginning at an average weight of 69 pounds and finishing at 115.9 pounds, made an average daily gain of 1.1 pounds on 3.22 pounds of feed per pound of gain.

Lot 2, of 12 pigs self-fed corn, tankage, and minerals on carpet-grass pasture, starting at an average weight of 69.1 pounds, finished at 140.8 pounds and making average daily gains of 1.7 pounds required 3.91 pounds of feed per pound of gain.

Lot 3, of 13 pigs on a limited ration of corn, tankage, and mineral for four weeks, followed by full feeding for two weeks on oats pasture, starting at an average weight of 70.9 pounds, finishing at 130.3 pounds, made an average daily gain of 1.4 pounds on 2.62 pounds of feed per pound of gain.

Lot 4, self-fed corn, tankage, and mineral on oat pasture, started at an average weight of 70.6 pounds and finished at 141.8 pounds, making an average daily gain of 1.7 pounds on a feed consumption of 3.56 pounds per pound of gain.

At the Iberia Livestock Experiment Farm, Jeanerette, La., 15 purebred Tamworth sows were maintained. Spring 1927 pigs were used in coop-

erative soft-pork investigations in the feeding of different proportions of corn and soy beans. After reaching weights of approximately 200 pounds, these hogs were shipped to Beltsville for slaughter and grading.

Twelve pigs on corn and tankage beginning at an average initial weight of 94 pounds fed through a period of 112 days made final weights of 204 pounds with an average daily gain of 0.97 pound on a feed consumption of 5.58 pounds per pound of gain.

Twelve pigs fed corn and soy beans in the proportion of 12 to 1 with a starting weight of 94 pounds reached final weight of 205 pounds with an average daily gain of 0.98 pound with a feed consumption of 4.88 pounds per pound of gain.

Twelve pigs fed corn and soy beans in the proportion of 9 to 1 starting at an average weight of 93 pounds finished at 205 pounds with an average daily gain of 1 pound required 4.7 pounds of feed per pound of gain.

Investigations in the study of soft pork were carried on in cooperation with the States of Virginia, North Carolina, South Carolina, Georgia, Mississippi, Arkansas, Tennessee, Indiana, Ohio, Michigan, and California. During the year 699 hogs were shipped to Beltsville for slaughter, physical grading of the carcasses, and laboratory study of the fats.

HORSE INVESTIGATIONS

The project to study the breeding, feeding, and management of Morgan and other light horses was continued at the United States Morgan Horse Farm, Middlebury, Vt., where a stud of 65 horses and colts was maintained.

The quality of animals produced in this stud has shown constant improvement as indicated by the continuous demand for breeding stock and by the prizes won at various exhibitions when placed in competition with other animals. Carefully worked-out matings have made it possible not only to improve the blood lines, but also to improve the average excellence of the animals produced. There has been a gradual increase in the weight and height of these horses.

The annual mounted endurance tests were discontinued this year, but in a local endurance ride held in connection with the Rutland fair, the United States Morgan Horse Farm mare Jana won the 80-mile endurance ride in the record time of 8 hours and 34 minutes.

At the United States Range Livestock Experiment Station, Miles City, Mont., investigations in horse-husbandry problems pertaining particularly to the West have been conducted along various lines. During the year a stud of 157 horses and mules was maintained. Sixty-six of these animals are federally owned, and 91 are the property of the State of Montana.

During the year preliminary studies were inaugurated in cooperation with the War Department with a view to determining the possibility of utilizing the facilities of the various Army posts in conducting horse-feeding work. A feeding test was inaugurated at Fort Myer, Va., with the object of determining the possibility of establishing variations from the standard ration used in the Army, with the aim of reducing the costs of feeding horses. Three troops of cavalry horses and three batteries of artillery horses were assigned for this test.

The data obtained in this work have not yet been compiled.

CERTIFICATION OF ANIMALS IMPORTED FOR BREEDING PURPOSES

Under the provisions of paragraph 1506 of the tariff act of 1922 the bureau issued certificates of pure breeding for 410 horses, 5,986 cattle, 2,710 sheep, 30 swine, 2,157 dogs, and 8 cats during the fiscal year ended June 30, 1928. The total, 11,301 animals, is 55 per cent greater than the number certified in the previous year.

POULTRY INVESTIGATIONS

POULTRY BREEDING

Material progress was made during the year in studies in the inheritance of egg production in Rhode Island Reds and Single Comb White Leghorns. The average egg production to date in both breeds is higher than for the same period of any previous year. The size of the egg laid has been increased in both breeds, owing to the rigid selection of the breeding stock on that basis. The highest individual record of egg production was 317 eggs laid by a Single Comb White Leghorn pullet.

The fertility and hatching results in the two breeds were somewhat lower than in 1927. In the Rhode Island Reds in 1927 the percentage of fertile eggs was 94, whereas in 1928 it was 89, and in the Single Comb White Leghorns the percentage decreased from 88 to 81. The percentage of fertile eggs hatched in the Rhode Island Reds

in 1927 was 71, and in 1928 it was 67, whereas in the Single Comb White Leghorns the percentage decreased from 70 to 58.

The rearing results were practically the same in 1928 as in the preceding year. In the case of both breeds approximately 96 per cent of all chicks hatched were alive at 5 weeks of age. These results have been gratifying.

The studies in inbreeding with four pens each of Barred Plymouth Rocks and Single Comb White Leghorns have been continued. The results to date demonstrate clearly that such close inbreeding as full-brother-and-sister and half-brother-and-sister matings cause the pullets raised each succeeding year during which inbreeding is continued to mature at a slower rate. Average annual egg production decreases, and hatching results each succeeding year are poorer. One of the most outstanding results of the effect of continuous close inbreeding has been the increase in the percentage of embryo mortality during incubation.

The studies in hatchability have revealed that egg production preceding the hatching season, at least if no longer than for four or five months, does not affect hatchability, nor does antecedent egg production affect chick mortality up to four weeks after hatching. The results also show that there is no correlation between fertility and hatchability, and that causal factors affecting hatchability do not significantly affect chick mortality up to four weeks after hatching.

Causal factors affecting embryo mortality up to the seventeenth day of incubation and chick mortality up to four weeks after hatching are shown to be unrelated; nor is there any relation between embryo mortality during the last three days of incubation and chick mortality up to four weeks after hatching. Full-brother-and-sister matings and half-brother-and-sister matings tend to decrease hatchability by increasing both the percentage of embryos dying during the period from the first to the seventeenth days and the percentage of embryos dying between the eighteenth and twenty-first days of incubation. Such close inbreeding affects embryo mortality from the eighteenth to the twenty-first days of incubation to a greater extent than embryo mortality from the first to the seventeenth days of incubation.

Hatchability results are affected to a greater extent in the first year of inbreeding than in successive years, though there is a general decline in

hatching results each year that such close inbreeding is continued.

POULTRY FEEDING

In the fall of 1927, as a continuation of the work done during the two preceding years, 12 lots of White Leghorn pullets were started on the project to determine the protein requirements of laying hens. The results previously obtained indicated that the best level of protein, in rations compounded chiefly of corn meal, mineral mixture, and either meat meal or dried skim milk, was about 20 per cent. There was also some indication that the utilization of the protein might be dependent upon the relative amounts of calcium and phosphorus in the feed. Therefore, rations containing 20 per cent protein and having six different calcium-phosphorus ratios were used. Up to the end of the fiscal year the best results were obtained when the mineral mixture contained ground limestone and steamed bone meal in the ratio of 4 to 1.

Two experiments, of 14 weeks' duration, were conducted with White Leghorn chicks to determine the protein requirements of growing chicks; 14 lots of 40 chicks each were used in each experiment. The results of the work of the two preceding years indicated that the calcium-phosphorus ratio of the ration (compounded chiefly of corn meal, mineral mixture, and either meat meal or dried skim milk) was an important factor in the growth of the chicks and the occurrence of leg weakness. Therefore rations containing 19.5 per cent protein (seven containing meat meal and seven containing dried skim milk) and having different calcium-phosphorus ratios were fed. Each of the several rations contained 1 per cent of cod-liver oil. In general, the chicks grew best on the rations containing dried skim milk but the growth of the chicks did not seem to be markedly affected by the different calcium-phosphorus ratios.

In the second experiment the rations containing meat meal were again used, but this time the mineral mixture in some of the rations contained 2 per cent of ferric sulphate, while that in the others contained no added iron salts. Again the calcium-phosphorus ratio seemed to have no marked effect on growth, but in those pens in which ferric sulphate was used there were more cases of leg weakness than where it was not used. The addition of 15 per cent of midlings to the ration, both when it

contained ferric sulphate and when it did not, had a marked tendency to prevent leg weakness and enabled the chicks to make somewhat better growth.

A study of the effect of feeding certain sulphur compounds on the molting of hens and on the total annual egg production was continued by starting a third set of pens in this experiment. The results obtained to date have been very gratifying. The data indicate that the particular mixture of inorganic sulphur compounds fed was instrumental in increasing the annual egg production approximately 13 per cent in each of three experiments.

Three experiments were conducted to learn the gross maintenance requirement of chickens. In one of them, individual hens instead of groups of hens were used. The average maintenance value of the food, as determined by this experiment, agreed closely with the values previously determined with groups of 10 hens. However, the data exhibited considerable variability and for that reason it was concluded that, in this type of experiment, it is safer to use groups of hens rather than individuals. In the other two experiments, groups of chickens of different average live weights were fed at a level of feed intake appreciably lower than the maintenance level. The data thus secured failed to show any relationship between loss in live weight and the original average live weight of the chickens.

In a comparison of ultra-violet irradiation and cod-liver oil for laying hens kept in confinement, six pens of Rhode Island Reds were used. The hens were kept in confinement and were not permitted to have access to direct sunlight. The pens receiving ultra-violet irradiation and those receiving cod-liver oil have given better egg production and maintained heavier body weight than the pens receiving only a normal ration. The effect on hatchability, egg weight, and shell weight are also being studied in this work, which is still in progress.

BIOCHEMICAL DIVISION

The work of the Biochemical Division, under M. Dorset, chief, consisted for the most part of chemical and bacteriological researches on problems concerning dips and disinfectants, hog cholera, tuberculin, and mallein, and meats and meat food products.

INVESTIGATIONS OF DIPS AND DISINFECTANTS

Routine laboratory analyses were made of 326 samples of disinfectants, dips, viruses, serums, and miscellaneous products.

FIELD TESTS FOR DIPPING BATHS

During the year there were prepared and forwarded to inspectors in the field the following: For testing the strength of dipping baths, 563 new test outfits for arsenical dips and supplies sufficient to make 501,000 field tests; supplies sufficient to make 5,800 tests of lime sulphur dips; 6 new outfits for testing nicotine dipping baths and supplies sufficient to make 3,645 tests; supplies sufficient to make 5,200 tests for phenol in viruses, serums, and analogous products.

MODE OF ACTION OF DISINFECTANTS

In studies of the relation between chemical constitution and germicidal activity of various classes of organic compounds, work with a number of alkyl and aryl amines, alkyl ketones, and aldehydes has been completed. The list of substances which have so far been tested now comprises alcohols, phenols, resorcinols, aldehydes, ketones, and amines.

The results taken as a whole show that, with the one exception of primary alkylamines with *Bacillus typhosus* as the test organism, a similarity in ratios exists in all the classes of compounds thus far studied. This similarity indicates that the bactericidal power of any member of the different series investigated is affected essentially to the same degree by the introduction of a methyl group. Definite chemical and germicidal relation of these classes of compounds to one another was indicated.

It was found that saponified cresol solutions when made by the method of the United States Pharmacopœia, which advocates mixing all the ingredients together and heating them at 70° C., may contain as much as 30 per cent of the oil unsaponified and at the same time pass the dilution test. The saponification of the oil was not completed even when heated for 24 hours at 70°. Increasing the working temperature from 70° to 98° makes it possible to finish the process in about one-fourth the time. The rate of saponification of linseed oil varied when car-

ried out in the presence of the various phenols, being slowest with the lowest phenol.

A number of substances were tested in searching for an odorless and cheap disinfectant for chicken houses and incubators. Dilute solutions of sodium hydroxide, with and without soap, were found to kill *Salmonella pullorum* and other organisms pathogenic to chickens and should be given more extensive trial.

MECHANISM OF THE ACTION OF SOAPS

Work was directed during the year toward the study of detergency, or cleansing power, to determine whether it can be correlated with deflocculation or emulsification. So far the correlation seems to be decidedly imperfect. It appears that the cleansing power of a soap or similar agent must be determined through actual experiments on soiled goods, not through inference from its power to deflocculate powders or to emulsify oils. A special laboratory washing machine was devised, as well as an apparently new conversion of a colorimeter into a reflectometer for evaluating the residual soil on washed goods.

DISINFECTION OF SAUSAGE CASINGS

B. A. I. Order 305, issued March 7, 1927, prohibited the importation of sausage casings without certification, provided, however, that uncertified casings might be imported if suitably disinfected. The Biochemic Division, in the fall of 1927, took up the study of disinfecting of sausage casings and developed a method which has since been applied in practice and found to be satisfactory. This method consists in the disinfection of the casings by a solution containing 1 per cent hydrochloric acid and 10 per cent sodium chloride. The disinfectant is efficient and does not appear to injure the quality of the casings. The disinfectant and the method of applying it are described fully in B. A. I. Circular Letter 1501, dated November 26, 1927.

CHLORINATION OF TANNERY EFFLUENTS

The chlorination of tannery effluents to guard against the possible dissemination of anthrax promises to be increasingly employed. The object of this disinfection is important enough to warrant further experiments, particularly in varying the dosage of chlo-

rine to correspond to variations in the character of different effluents and to the time of holding which various tanneries can give to the chlorinated effluent before its discharge.

TUBERCULIN AND MALLEIN

The preparation and distribution of tuberculin and mallein for official use by bureau and State inspectors was continued. During the year the total quantity of mallein supplied was equivalent to 17,200 doses, constituting approximately 2,000 fewer doses than were supplied during the preceding year.

PRODUCTION OF TUBERCULIN

The year's output of tuberculin was as follows: Subcutaneous tuberculin, 420,430 cubic centimeters; intradermic tuberculin, 2,259,380 cubic centimeters; ophthalmic tuberculin, 2,881,680 disks. The total production of tuberculin in all forms during the year amounted to approximately 14,283,687 doses. During the year some improvements in the technic of tuberculin production were instituted.

BACTERIAL METABOLISM

It was previously reported that the change in reaction which is seen in tubercle cultures from acid to alkaline depends on the rate of growth of the bacilli. Further studies of various culture media have shown that while the principle holds good for the particular culture medium which was being used at that time, it now seems to be established that under other circumstances that rule does not hold good. Some of the most rapid-growing cultures may never become acid in reaction. During these studies of the metabolism of tubercle bacilli it has been shown that the rate of growth of *Mycobacterium tuberculosis* on the synthetic media which are being employed is greatly increased by the presence of dextrose. Cultures on dextrose media make about three times as much growth during the first three weeks as bacteria which are grown on control media without dextrose. Of numerous sugars studied, this property seemed to be peculiar to dextrose. One per cent of dextrose appeared to be necessary to produce the maximum effect on the rate of growth.

The reaction curve of tubercle bacilli on the synthetic medium used is greatly influenced by the amounts and the relative proportions of glyce-

rin and asparagine contained in the medium. If the proportion of glycerin is too great, the cultures will become acid after an initial alkalinity, while excess of asparagine will result in the cultures' remaining neutral or alkaline.

One of the prime objects of the studies of bacterial metabolism was to obtain more luxuriant cultures of *M. tuberculosis*, with the expectation that more abundant growth per unit volume of culture medium would result in a greater yield of the active substances needed in tuberculin for cattle testing. This work has been very encouraging and it has finally been possible to produce a culture medium which yields regularly 2 grams of bacteria dry weight per 100 cubic centimeters of culture fluid in six weeks. This is at least 30 per cent more growth than has ever been reported by any other laboratory.

VITAMINS IN MEAT AND MEAT FOOD PRODUCTS

Continued study of the vitamins of meats and meat products has yielded interesting results. It was reported several years ago that pork was well supplied with the antineuritic vitamins, whereas beef contained comparatively little. At that time both the antineuritic and the growth-promoting functions were looked upon as different properties of the same vitamin, usually designated "vitamin B." Recently, however, Goldberger and associates of the United States Public Health Service seem to have proved that the water-soluble B vitamin really consists of at least two separate factors: (1) The antineuritic vitamin, which is injured or destroyed by heat, and (2) the heat-stable vitamin, which is probably identical with the one which cures black tongue in dogs and pellagra in man. Both of these vitamins are essential for growth and health. Those findings made it desirable to go over and extend the earlier work on vitamin B in meats. As a result of numerous experiments with pigeons and rats, lean pork proved to be an excellent source of the antineuritic vitamin, being fully as rich in this vitamin as brewer's yeast and richer than baker's yeast. Beef, however, contained much less of this vitamin. These results are in accord with those previously reported from this laboratory.

Lean pork was found to be a good source of water-soluble B vitamin, comparing very favorably in this respect, on a dry-matter basis, with the

whole cereals, but it is not so rich in the complete water-soluble B vitamin as is yeast. Therefore, although lean pork has been found to be fully as rich as the antineuritic vitamin as brewer's yeast, yet these findings indicate that yeast is richer in the heat-stable portion of the water-soluble B vitamin.

Lean beef was found to be much poorer in complete water-soluble B vitamin than pork. From 40 to 70 per cent of dried, lean beef was required to furnish sufficient water-soluble B vitamin for excellent growth in rats, whereas from 15 to 20 per cent of dried, lean pork will accomplish the same result.

An extract, prepared in the laboratory from fresh, lean pork, was found to be an excellent source both of the antineuritic and of the water-soluble B vitamins. The extract, which was concentrated to the consistence of fluid beef extract, was similar in appearance and taste to beef extract except that it gelatinized on cooling. A single dose of 0.2 gram of pork extract (dry-matter basis) usually restored polynuritic pigeons to normal and a daily dosage of 0.2 to 0.4 gram of the extract furnished sufficient water-soluble B vitamin for excellent growth in rats.

Commercial beef extract has been found to be a good source of the heat-stable, water-soluble B vitamin, but it is poor in the antineuritic vitamin. A ration containing 10 per cent of an alcoholic extract of corn has the source of the antineuritic vitamin induced only slight growth in rats, and similar results were obtained with a ration containing 20 per cent of beef extract, yet when 5 per cent of corn extract was mixed in a ration with 5 to 10 per cent of beef extract the rats made excellent growth. Similar results have been obtained with beef extract from three establishments.

Further study of rancidity in fats has shown that if care is not taken with regard to the purity of reagents mistakes may be made. It was found that the presence of nitrosyl chloride in hydrochloric acid causes false reactions.

HOG-CHOLERA INVESTIGATIONS

During the year there were prepared at the experiment farm, Ames, Iowa, 95,000 cubic centimeters of anti-hog-cholera serum and 34,865 cubic centimeters of virus. These products were used in connection with the experi-

ments being carried on at Ames, as well as in connection with the experimental immunization of young pigs at the various farms operated by the Animal Husbandry Division. The spring and fall litters of pigs at these farms were immunized by the simultaneous method, with satisfactory results. Since it has been suggested that some of the unsatisfactory field results with immunization are caused by the serum being too old at the time it is used, the division tested during the year three defibrinated-blood serums and three clear serums. These samples had all passed the age limit by periods ranging from three months to one year. The samples, when subjected to the regular 8-pig serum test, were all found to be of satisfactory potency.

During the year a remedy consisting of calomel, ipecac, and soda was tried on a few cholera-infected pigs. In one experiment four sick pigs on a farm where cholera prevailed were selected and given treatment. One of these died before the treatment was finished and the other three succumbed one or two days later. In the test at the bureau's experiment station two pigs were treated and one was kept as a control. All three of the pigs became sick and died of hog cholera. The foregoing test seemed to demonstrate conclusively that calomel, ipecac, and soda had no effect on the progress of hog cholera.

THE SIMULTANEOUS AND SERUM-ALONE METHODS IN THE TREATMENT OF CHOLERA-INFECTED HERDS

Five experiments were carried out in which 64 shotes were used. The general plan was to inject a series of susceptible shotes with virus. On the second, third, or fourth day thereafter a certain number of infected shotes were selected, one half being treated with serum alone, the other half being given the simultaneous treatment. A day or two later another lot of infected pigs was withdrawn, one half being treated with serum alone and the other half being given the simultaneous inoculation of serum and virus. The remainder of the original series of pigs were left untreated as controls. Full doses of serum were used in these experiments. When the simultaneous treatment was administered, the usual 2-cubic centimeter dose of virus was given. In this experiment there was little difference in the results seen between the simultaneous and the serum-alone treat-

ment when administered to cholera-infected hogs from two to four days after infection.

FURTHER STUDIES OF FORMALINIZED VACCINES

A study of formalinized vaccines prepared from the fluids and tissues of the carcasses of hogs affected with cholera has been continued, with variable results. At times the protection has been almost perfect; at others it has not been sufficient to warrant the use of the method in practice. Further study is being given this subject to determine the causes of these irregularities.

STUDIES OF "BREAKS" IN IMMUNITY

The study of "breaks" in immunity is one of the most important in connection with swine diseases. In determining the effect of *B. suispestifer* and *B. suissepticus* upon breaks at the time of treatment—in other words, "early breaks"—susceptible pigs have been injected simultaneously with serum, virus, and cultures of the two organisms named. In two out of four experiments with cultures of *B. suispestifer* the investigators produced very definite, early breaks in immunity—that is to say, the serum failed to protect completely against the virus and culture. In the third experiment there was a slight break—that is, slight illness of the injected pigs. The fourth experiment was without result. In two experiments, using *B. suissepticus*, there was no evidence of a break in immunity.

Late breaks were studied in much the same way, except that in this case no serum was injected at the time the culture was used. In these cases a number of pigs were immunized in the regular way with serum and virus and after an interval of one to six months these pigs were tested by injecting them with mixtures of hog-cholera virus and *B. suispestifer* cultures. Out of three experiments one very definite break was produced, in one experiment there was a slight reaction, whereas in the other there was no effect. Attempts to produce late breaks with *suissepticus* cultures were unsuccessful.

While the experimental work is not extensive, both early and late "breaks" apparently may occur in supposedly immune shots which are exposed simultaneously to virulent strains of *B. suispestifer* and hog-cholera virus.

MISCELLANEOUS STUDIES

A number of field cases of necrotic enteritis have been investigated and the effect of *B. suispestifer* in reproducing the condition has been studied. It has been evident that *B. suispestifer*, as it occurs in nature, varies greatly in its pathogenic properties. Some of the strains isolated had comparatively little effect upon pigs, whereas others possessed great virulence. There is no doubt that certain members of the *suispestifer* group are capable of causing very severe enteritis in pigs.

A variety of experiments relating to different phases of hog cholera have been carried out, including transmission of the disease by flies, study of the infectiveness of the blood of recovered pigs, and a study of the effect of alkaline soap on the virus of hog cholera.

BACILLARY WHITE DIARRHEA

During the year there was organized a new project which has as its ultimate object the control or eradication of bacillary white diarrhea of young chickens. This work was taken up in cooperation with the national poultry interests by a committee of three, selected by the chief of bureau, from the Biochemic Division, Pathological Division, and the Animal Husbandry Division. The investigation is being conducted at the bureau's experiment station at Bethesda, Md.

EXPERIMENT STATION

The work of the bureau's experiment station at Bethesda, Md., was conducted under E. C. Schroeder, superintendent, until his death, January 24, 1928. During the remainder of the year W. E. Cotton, who succeeded him, directed the station's various activities. In the work of investigating infectious diseases of animals, special attention was given during the year to abortion disease, tuberculosis, and vesicular stomatitis.

BOVINE INFECTIOUS ABORTION

The work on bovine infectious abortion that has been in progress in the pathological division was transferred to the experiment station in the last quarter of the year, and this report covers the work for the year performed both by that division and by the experiment station.

The significance of *Bacterium abortus* for human health has become a matter of concern as the list of reported cases of undulant fever attributed to this organism slowly increases. Proof that it can infect a human being and cause a very serious disease was forcibly brought to the attention of the station by one of its employees suffering from an attack of undulant fever due to *B. abortus*. The organism recovered from his blood by the Hygienic Laboratory of the Public Health Service has been found, by guinea-pig inoculation at the experiment station and by cultural tests made at one of the State experiment stations, to be of the swine type.

Although cases of human infection have not definitely been traced to *B. abortus* infection in milk, the circumstantial evidence that this has been responsible for some of them is fairly strong. The extent and the sources of human infection and the means of preventing it are subjects that demand prompt and thorough investigation.

The investigation begun last year to determine the efficacy of attenuated bovine strains and swine strains of *B. abortus* for producing immunity against abortion disease in cattle has been continued and the first stage of it concluded. The results from the limited number of animals used indicate that one strain which lost its virulence for guinea pigs and apparently so for cattle through long-continued cultivation on artificial media, but which is still highly sensitive to the agglutinins of positive abortion sera, will, if given subcutaneously to pregnant cows and heifers, afford a marked degree of protection against exposure to abortion infection. The results indicate also that a virulent swine strain will afford even more protection, but both strains, when given three months before conception, produced only a slight immunity. In contrast to this, several animals vaccinated with a recently isolated bovine strain before conception produced normal calves without infected placentas, whereas two-thirds of the controls aborted.

The swine strain caused the udder of one of the animals vaccinated before conception and that of one of those vaccinated after to become infected with the vaccine strain. The udder of one of the animals receiving the recently isolated bovine strain also became infected, but whether from the

vaccination or from the exposure was not determined.

Though the swine strain, when used on pregnant animals, was efficacious in preventing abortion, it caused udder infection with a type of the abortion organism not known to infect naturally the udders of cows. There is good reason to believe that this type may be more pathogenic for man than the bovine type, the one that naturally invades the udders of cows; hence, the use of the swine strain of *B. abortus* as a vaccine for cattle is condemned altogether.

The fact that abortion bacilli used in vaccination may reach the udder should be kept in mind in the selection of strains used for vaccine, and all strains of unusual virulence, or not proved to be typically bovine, excluded.

Studies relating to the efficacy and practicability of immunizing bovine animals against infectious abortion during calthood, as a means of rendering them more resistant to the disease during maturity, have been continued. Eleven calves which received a single injection of abortion vaccine during 1925 have now completed their first gestation periods. Following an exposure during pregnancy to *B. abortus* of sufficient intensity to cause 3 of 5 controls to abort, the 11 heifers vaccinated during calthood produced 11 living calves.

Three of the calves received vaccine prepared from a recently isolated strain of *B. abortus*; three others received vaccine prepared from a strain that had been propagated on artificial medium for a period of approximately two years, and the remaining five were vaccinated from strains that had been propagated on artificial medium for a period of 8 years.

Whereas the vaccine prepared from the most recently isolated strain appeared to localize and persist in the udder of one of the vaccinated calves for a prolonged period, the vaccine made from the strains longer under artificial cultivation failed to manifest this characteristic, indicating that strains of somewhat reduced virulence may be more appropriate for immunizing procedures.

Studies have been made also of the effects of vaccination in a herd of about 300 dairy cattle where for a period of 10 years a practice has been made of vaccinating the heifers produced about two months previous to their breeding. Although there have been additions to this herd of a con-

siderable number of cows and heifers which have aborted in almost 18 per cent of their pregnancies, the abortion rate in 149 vaccinated animals during the 10-year period in which vaccination has been practiced has been but slightly over 5 per cent.

Studies are in progress to determine whether certain adaptations of *B. abortus* to artificial environments are lost when the organism is returned to its natural habitat.

Many blood tests have been made in connection with efforts to free herds from abortion infection and to keep them free. The data obtained from these promise to be of much value in working out practical methods for the eradication and control of abortion disease.

TUBERCULOSIS

Studies on so-called skin tuberculosis of cattle and its relation to the tuberculin reactions have been continued and a paper on one phase of the subject published.

The investigation to determine the value of the Calmette B. C. G. vaccine as an immunizing agent against tuberculosis has been continued in cooperation with the Hygienic Laboratory of the Public Health Service. A number of calves, either fed or injected with the B. C. G. vaccine within the first 10 days of life, have been, with an equal number of controls, given natural exposure by association with tuberculous animals. It is planned to add to the number of treated and control animals from time to time as calves become available, born both in and out of a tuberculous environment. In addition to the foregoing, a large number of guinea pigs, treated in a similar manner, have been exposed, with controls, to tuberculosis through feeding.

The work of the year has not developed anything to change the opinion expressed in the last report to the effect that, while vaccination with B. C. G. increases resistance against tuberculosis infection, it does not provide anything approaching complete immunity, and that, while it may be found to be of value in countries where the disease can not be eradicated except at a prohibitive expense, it does not follow that its use in the United States, with its relatively small percentage of tuberculosis, will be justified.

As in former years, commercial tuberculins have been tested for potency and efforts to simplify and im-

prove the method of testing them have been continued.

VESICULAR STOMATITIS

The investigation of vesicular stomatitis has been continued not only because of the direct loss that it may at times cause but more particularly because of its close relation in so many respects to foot-and-mouth disease and the danger of mistaking the one disease for the other.

There are at least two distinct strains of the virus, recognizable through the immunity each induces against itself but not against the other strain. The two strains thus far discovered have been kept alive by passage through guinea pigs, and have remained pure so far as can be determined. One of the strains has been at the station for over three years and in that time has been passed through guinea pigs more than three hundred and sixty times and still seems to be as virulent for both guinea pigs and cattle as when first collected from a natural outbreak.

The immunity in guinea pigs conferred by an attack of the disease is strong and lasting, continuing for as long as 14 months.

It has been found that diluted vesicular fluid dropped in the eye of a guinea pig will not cause visible lesions, but will in a considerable proportion of cases cause a marked thermic reaction. This treatment is followed by a fairly strong and lasting immunity in nearly all cases. Attempts to immunize cattle by the same methods have been successful in some of the cases treated.

FIELD INSPECTION DIVISION

The Field Inspection Division continued to conduct the field work incident to control and eradication of certain diseases of livestock. This work includes the enforcement of livestock quarantine and transportation laws, the administration of regulations governing the importation and exportation of livestock and those providing for the sanitary handling of hides, skins, wool, and other animal by-products, feeding materials, fertilizers, used bagging, and hay and straw packing materials offered for importation into the United States. On January 1 A. W. Miller, former chief, was placed in charge of the Packers and Stockyards Division and George W. Pope succeeded him as chief of the Field Inspection Division.

EXCLUSION OF FOOT-AND-MOUTH DISEASE AND OTHER DISEASES OF FOREIGN ORIGIN

Efforts to guard against the introduction of foot-and-mouth disease have proved successful. There has been no occurrence of this disease in the United States since October 15, 1925, and the country has continued to be free from rinderpest, contagious pleuropneumonia, surra, and European fowl pest. A treaty, the terms of which were drafted in 1926 by representatives of the United States and Mexico and designed to safeguard the livestock interests through the adoption of uniform measures to prevent the introduction of communicable diseases, was ratified by the Senate of the United States in March, 1928, but will not become effective until ratified by Mexico.

EUROPEAN FOWL PEST

The country has remained free from European fowl pest during the year and no reports were received of any unusual disease in poultry. With a view to the prevention of outbreaks and the spread of serious poultry diseases, the bureau has continued to furnish supervision of the cleaning and disinfection of cars used in the interstate transportation of live poultry and on the request of shippers and poultry-car companies 12,836 cars were treated during the year.

ERADICATION OF SCABIES

In the work of eradicating sheep scabies which was continued in co-operation with State officials, inspectors in the field made 22,935,543 inspections and supervised 3,474,822 dippings of sheep. Sheep found to be infected numbered 676,281, which is approximately 27 per cent more than for the preceding year. An increase in the number of infected animals was reported in Arizona, New Mexico, Kansas, Utah, and California, and a reduction in the States of Colorado, Wyoming, Texas, and Nebraska. Excellent progress was made in Louisiana but the situation in Mississippi, Kentucky, and Michigan remained practically unchanged. Some additional infection was found in Virginia and several infected flocks were located in West Virginia and Maryland, where the disease had not previously been reported.

In cooperation with State officials bureau employees made 3,267,020 inspections and supervised 765,322 dippings for the eradication of cattle scabies. A total of 151,672 cattle were

found to be infected. In Nebraska, Montana, Oklahoma, and Wyoming there was an increase in the number of animals reported infected and outbreaks were reported in Arizona and California where none occurred during the preceding year. Less infection was found in New Mexico, Kansas, Washington, South Dakota, Texas, and Utah.

In addition to sheep and cattle scabies eradication, inspection extended also to 11,934 goats, 568 of which were found to be infected. All these diseased animals were in Texas. In Montana 4,875 horses were inspected for scabies, of which 369 were affected with the disease.

ERADICATION OF DOURINE

Dourine-eradication work was continued on the Navajo Indian Reservation in Arizona and in a small section of northern Montana, the only areas in which this disease is known to exist. One complete test was made of horses on that portion of the Navajo Reservation where dourine was found during the preceding year. The number of reactors to the test was less than a third of that in the former test, indicating a marked decline in the disease. Although the maximum price paid by the Office of Indian Affairs for a diseased horse was but \$3, the work of disposing of these animals through slaughter progressed in a fairly satisfactory manner. The vast area of rough and remote country on the Navajo Reservation and the open-range conditions have made the work in that section exceedingly difficult. The castration of approximately 1,700 surplus stallions has aided materially in eradication work. Tests made in Montana revealed the presence of but 12 reacting horses. This was only 1.1 per cent of the number tested and indicates that eradication of the disease there has practically been accomplished.

LIVESTOCK SANITARY WORK IN INTERSTATE COMMERCE

In the course of supervising the interstate transportation of livestock to prevent the spread of animal diseases bureau employees at market centers inspected 19,712,737 cattle, of which 16,449 were dipped under supervision in order that they might continue in interstate commerce. Sheep to the number of 21,380,842 were also inspected for communicable diseases, and of these 628,595 were dipped under bureau supervision to comply with the

regulations of the department or of the State at destination. Bureau employees also inspected 42,967,036 hogs and supervised the immunization and disinfection against hog cholera of 546,380 swine for feeding and breeding purposes.

The bureau continued its efforts to prevent the spread of hemorrhagic septicemia and reduce losses from that disease, especially in feeder and stocker cattle. Arrangements were made with transportation and stockyards companies, as in preceding years, for the cleaning and disinfection under bureau supervision of all railroad stockyards regularly used in the feeding, watering, and resting of livestock and also of sections of public stockyards in which that class of cattle is handled. With a view to reducing the susceptibility of the animals to hemorrhagic septicemia an effort was made also to enlist the cooperation of shippers, commission men, and traders in a movement to accomplish a more proper feeding, watering, and resting of feeder and stocker cattle.

Bureau veterinarians inspected 22,041 horses and mules, of which 5,770 were tested with mallein; none showed reactions. This work was done on request of transportation companies and shippers or to comply with laws of States to which shipments were destined.

There were received at bureau stations during the year 33,761 cars carrying animals affected with communicable diseases. In compliance with department regulations or on request of Canadian Government officials, State officials, or transportation companies 73,248 cars were cleaned and disinfected under bureau supervision.

Although no case of foot-and-mouth disease has existed in the United States since October, 1925, all ruminants and swine received at public markets were carefully inspected for that disease by experienced veterinary inspectors in order that prompt control and eradication measures might be initiated should an outbreak occur.

ENFORCEMENT OF TRANSPORTATION AND QUARANTINE LAWS

Inspectors of the bureau have continued to report alleged violations of the 28-hour law, which limits the time of confinement of animals in cars without feed, water, and rest. There were 284 cases of apparent violations of the law presented to the Attorney General for prosecution. Penalties amounting to \$29,000 were imposed in cases decided in favor of the Government. The evidence was collected, and the reports were prepared largely by employees of the bureau in connection with their regular duties at public stockyards. During the year 42 cases of alleged violations of the quarantine laws and regulations were also submitted for prosecution. Fines amounting to \$4,205 were imposed in the cases decided in favor of the Government.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS

Regulations promulgated on May 1, 1927, have continued to govern the importation of domestic livestock and other animals. There has been adherence to the established rule to issue no permits for the importation of domestic ruminants and swine from countries in which foot-and-mouth disease or certain other serious diseases of livestock exist. The utmost care has been taken in the inspection and quarantine of imported livestock. Following an importation of 50 sheep from England in July, there were repeated outbreaks of foot-and-mouth disease in that country. This made necessary a cessation of importations from England during the remainder of the year. Aside from those originating in Canada and Mexico, importations of domestic ruminants and swine were practically limited to purebred animals from the Channel Islands, Scotland, Norway, New Zealand, and Australia. The number and kinds of animals imported are shown in Tables 1 and 2.

TABLE 1.—*Imported animals inspected but not quarantined*

Port of entry	Cattle	Swine	Sheep	Goats	Horses and mules	Asses	Other animals
Boston.....					80		6
Galveston.....					3		
Houston.....							14
Key West.....					594		
Los Angeles.....					2		7
New York.....					921	17	20
Philadelphia.....					1		
San Francisco.....					3		1
San Juan, P. R.....	1,624	60			115	18	5
Tampa.....					3		
Canadian border ports.....	299,715	82,668	21,161	50	7,679	20	824
Mexican border ports.....	207,487	386	19,842	275	4,928	11	71
Total.....	508,826	83,114	41,003	325	14,329	66	948

¹ Of this number 3,337 were mules.

NOTE.—Mexican animals passed through United States territory under bond for return to Mexico and inspected at the time of entry were as follows: Cattle, 893; horses, 26; mule, 1; asses, 3.

TABLE 2.—*Imported animals inspected and quarantined*

Port of entry	Cattle	Swine	Sheep	Goats	Horses and mules	Asses	Other animals
Baltimore.....			58				27
Boston.....			58				109
Los Angeles.....						2	1
New York.....	1,040		103			4	127
San Francisco.....			183				13
San Juan, Porto Rico.....				1			
Canadian border ports.....	991	7	13				
Mexican border ports.....							
Total.....	2,031	7	415	1		6	277

Inspectors of the bureau, in cooperation with the Bureau of Biological Survey, inspected and quarantined at time of entry 84,965 quail imported from Mexico.

Tuberculin tests were applied to 1,040 cattle from Scotland and the Channel Islands prior to their release from quarantine. Of this number three reacted to the test and were slaughtered. Cattle from Canada for dairy or breeding purposes not accompanied by satisfactory tuberculin-test certificates were also tuberculin tested at time of entry. Of 991 Canadian cattle so tested, 48 reacted to the test and were refused entry.

Vigorous measures were taken to prevent vessels from entering ports of the United States with sea-stores livestock originating in countries in which foot-and-mouth disease or rinderpest exists. The cooperation of the United States Public Health Service was obtained whereby quarantine officers of that service obtained declarations of the masters of vessels having sea-stores animals on board, bringing the regulations to their attention and

notifying our inspectors at the port of the arrival of such vessels at quarantine. During the year 26 vessels were held before entry at various ports of the United States, and 46 prohibited animals, consisting of cattle, sheep, goats, and swine were slaughtered, followed by disinfection of the portion of the vessel they occupied.

IMPORTATION OF ANIMAL BY-PRODUCTS AND FEEDING MATERIALS

A continued effort has been made to guard against the introduction of livestock diseases, such as anthrax and foot-and-mouth disease, through the medium of imported animal by-products, forage, hay, and straw used for packing merchandise, previously used bagging, etc. These importations are numerous and involve such products as hides, skins, wool, and other materials which are required by domestic industries. A close supervision over the entry of such materials at various ports has been maintained, and, when not accompanied by proper certificates, provision is made for their proper han-

dling after arrival in the United States under careful sanitary requirements. These measures have afforded protection to domestic livestock without unnecessary inconvenience to the industries concerned.

INSPECTION OF ANIMALS FOR EXPORT

Every possible effort has been made to have export livestock meet the re-

quirements of receiving countries. All animals have been carefully inspected; dairy and breeding cattle have been tuberculin tested; and the fittings of transporting vessels have been supervised as provided by bureau regulations. There were 371 inspections of vessels before their clearance to foreign ports with livestock. The details are shown in Table 3.

TABLE 3.—*Inspection and testing of animals for export*

Kind of animals	To Canada	To other countries		Total
		American animals	Canadian animals ¹	
Cattle.....	1, 119	3, 492	25	4, 636
Swine.....	135	338	6	479
Sheep.....	65	12, 671	8	12, 744
Goats.....	5	64	4	73
Horses.....	1, 687	698	9	2, 394
Mules.....	105	7, 975		8, 080
Asses.....	4	58		62
Other animals.....		28		28
Total.....	3, 120	25, 324	52	28, 496

¹ Animals of Canadian origin exported through United States ports.

Practically all dairy and breeding cattle forwarded to Canada were tuberculin tested, and a large percentage of the horses and mules were subjected to mallein test prior to shipment. Further to meet requirements of the Canadian authorities, sheep, other than those for strictly breeding purposes and for immediate slaughter, were very generally dipped twice under supervision of a bureau inspector. Swine for export to Canada were, in nearly all instances, immunized against hog cholera before shipment.

DIVISION OF HOG-CHOLERA CONTROL

Activities for controlling hog cholera, which is the most serious disease of swine, were conducted by the Division of Hog-Cholera Control under U. G. Houck, chief, in a manner similar to that of recent years. In this work primary reliance is placed on the preventive-serum treatment administered for the most part by trained veterinarians.

The total number of hog-cholera outbreaks reported from all sources during the fiscal year was 6,689, which is a noteworthy decline from 11,555, the corresponding number for the fiscal year 1927. The division's activities consisted, as formerly, chiefly in the investigation and suppression of hog-

cholera outbreaks. A total of 36 veterinarians were employed during the year.

In the course of their investigations the inspectors performed 3,333 autopsies which resulted in 3,224 diagnoses of cholera. Following the discovery of infection, 1,106 farms were quarantined and 622 premises were cleaned and disinfected under supervision. In addition to the outbreaks of cholera the inspectors found also 1,438 cases of other swine diseases.

EDUCATIONAL ACTIVITIES

As a part of its hog-cholera-control work, the division has conducted a number of educational activities for the purpose of more widely disseminating information concerning means of prevention. Educational methods have included addresses, demonstrations, interviews, and the showing of motion pictures dealing with hog cholera. A new film entitled "This Little Pig Stayed Home" was prepared and released during the year.

By way of demonstrations, bureau inspectors treated 3,985 herds of swine, consisting of 93,423 hogs. A total of 9,392 persons attended these demonstrations. Practicing veterinarians were assisted in treating 444 herds containing 13,437 hogs.

In the performance of their duties the inspectors also attended 711 public meetings, 519 of which they addressed. Attendance at these meetings totaled 48,244 persons. Other field activities included: 88,528 interviews, 9,310 investigations on calls, and 15,355 visits to farms to survey conditions pertaining to hog cholera.

MEAT-INSPECTION DIVISION

The work of the Federal meat-inspection service, conducted under R. P. Steddom, chief, shows an increase of approximately 6.4 per cent in the total number of animals slaughtered, as compared with the number the previous year, and an increase of 2.45 per cent over the average total number of animals slaughtered during the past 10-year period.

GENERAL MEAT INSPECTION

Inspection was conducted at 829 establishments in 255 cities and towns as compared with 863 establishments in 258 cities and towns during the fiscal year 1927. Inspection was inaugurated at 33 establishments and withdrawn from 37, as compared with 25 and 64, respectively, during the preceding year. Inspection was withdrawn from these establishments on account of the discontinuance of slaughtering, interstate, or regular business, or upon request.

ANTE-MORTEM AND POST-MORTEM INSPECTIONS

The numbers of animals inspected, ante mortem and post-mortem, are given in Tables 4 and 5.

TABLE 4.—*Ante-mortem inspection of animals*

Class	Passed	Suspected ¹	Condemned ²	Total
Cattle.....	8,781,463	259,784	92	9,041,339
Calves.....	4,758,617	8,154	30	4,766,801
Sheep.....	12,980,630	3,193	20	12,983,843
Goats.....	20,389	8	—	20,397
Swine.....	48,222,865	132,542	2,719	48,358,126
Horses.....	106,748	17	23	106,788
Total.....	74,870,712	403,698	2,884	75,277,294

¹ This term is used to designate animals suspected of being affected with disease or condition that may cause condemnation in whole or in part on special post-mortem inspection.

² For additional condemnations, see Tables 5 to 9, inclusive.

TABLE 5.—*Post-mortem inspection of animals*

Class	Passed	Condemned	Total
Cattle.....	8,970,674	69,354	9,040,028
Calves.....	4,764,153	9,934	4,774,087
Sheep.....	12,968,477	15,364	12,983,841
Goats.....	20,334	62	20,396
Swine.....	48,193,218	154,175	48,347,393
Horses.....	106,464	301	106,765
Total.....	75,023,320	249,190	75,272,510

Tables 6, 7, and 8 show the diseases and number of condemnations on ante-mortem and post-mortem inspections.

TABLE 6.—*Diseases and conditions for which condemnations were made on ante-mortem inspection*

Cause of condemnation	Cattle	Calves	Sheep	Swine	Horses
Abscess.....				64	
Asphyxia.....				4	
Blackleg.....	1				
Bone disease.....				5	
Car sickness.....	3				
Emaciation.....	13	1		15	
Enteritis.....				7	
Gangrene.....				1	
Hog cholera.....				1,603	
Immaturity.....		12			
Injuries.....	9	4	4	2	
Mammitis.....	1				
Metritis.....				2	
Moribund.....	22	10	7	31	
Pneumonia.....	3		2	77	
Pyrexia.....	26	2	5	841	
Recent parturition.....	1				
Rumenitis.....	1				
Septicemia and pyemia.....	11	1	2	66	1
Strangles.....					20
Tetanus.....				1	2
Tympanitis.....	1				
Total.....	92	30	20	2,719	23

TABLE 7.—*Diseases and conditions for which condemnations were made of the entire carcass on post-mortem inspection*

Cause of condemnation	Carcasses					
	Cattle	Calves	Sheep	Goats	Swine	Horses
Actinomycosis.....	353	38			1	
Anthrax.....		1			74	
Asphyxia.....		1	2		1,387	
Blackleg.....	6	11				
Bone diseases.....	112	133	250		6,297	1
Car sickness.....	2					
Caseous lymphadenitis.....			1,763	16		
Cellulitis.....					44	
Contamination.....	1	4	2		1,015	
Cysticercus.....	121	19	141		57	
Dropsical diseases.....	43	1	22		19	
Emaciation.....	6,772	1,510	3,724	28	1,017	19
Gangrene.....	36	30	1		4	
Hog cholera.....					17,723	
Hydronephrosis.....					56	
Icterus.....	112	136	1,034	1	4,193	
Immaturity.....		3,199			8	10
Injuries, bruises, etc.....	3,598	715	615	3	1,270	30
John's disease.....	5					
Leukemia.....	931	27	7		188	
Melanosis.....	24	43	16		104	1
Moribund.....	16	3	17		31	
Necrobacillosis.....	5		6		1	
Necrosis.....	8		3			
Parasitic diseases.....	26	1	3		89	
Phlebitis.....		49				
Pneumonia, peritonitis, enteritis, pleurisy, etc.....	10,917	2,103	6,224	8	38,967	103
Pregnancy and recent parturition.....	31		41	1	13	17
Septicemia, pyemia, uremia, etc.....	5,115	1,040	1,293	2	20,120	58
Sexual odor.....				3	3,051	
Skin diseases.....					101	
Strangles.....						1
Texas fever.....	63	100				
Tuberculosis.....	38,931	595	1		55,749	
Tumors and abscesses.....	2,126	175	224		2,596	59
Total.....	69,354	9,934	15,364	62	154,175	301

TABLE 8.—*Diseases and conditions for which condemnations were made of parts of carcasses on post-mortem inspection*

Cause of condemnation	Parts of carcasses					
	Cattle	Calves	Sheep	Goats	Swine	Horses
Actinomycosis.....	93, 772	1, 741	3	-----	1	-----
Bone diseases.....	26	5	-----	-----	58	-----
Caseous lymphadenitis.....	-----	-----	28	2	-----	-----
Cellulitis.....	-----	-----	-----	-----	911	-----
Contamination.....	111	12	6	-----	3, 578	-----
Cysticercus.....	584	10	1	-----	-----	-----
Injuries, bruises, etc.....	648	80	69	1	14, 393	-----
Melanosis.....	16	3	-----	-----	1	-----
Necrobacillosis.....	-----	-----	-----	-----	1	-----
Necrosis.....	1, 406	-----	-----	-----	-----	-----
Parasitic diseases.....	74	-----	-----	-----	-----	-----
Tuberculosis.....	59, 242	557	-----	-----	518, 414	-----
Tumors and abscesses.....	5, 214	1, 071	63	1	340, 154	2
Total.....	161, 093	3, 479	170	4	877, 511	2

Table 9 shows the total combined condemnations on ante-mortem and post-mortem inspections.

TABLE 9.—*Summary of condemnations*

Class	Live animals and whole carcasses	Parts of carcasses
Cattle.....	69, 446	161, 093
Calves.....	9, 964	20
Sheep.....	15, 384	170
Goats.....	62	4
Swine.....	156, 894	877, 511
Horses.....	324	2
Total.....	252, 074	1, 038, 800

In addition the carcasses of 54,766 animals found dead or in a dying condition were tanked, as follows: Cattle, 4,246; calves, 3,640; sheep, 9,185; goats, 32; swine, 36,894; horses, 769.

INSPECTION OF MEAT AND PRODUCTS

The inspection and supervision of meat and products prepared and processed are shown in Table 10, which is a record only of inspection performed and not a statement of the actual quantity prepared. The record of inspection is sometimes duplicated when the product is reinspected during the different stages of preparation.

TABLE 10.—*Meat and meat food products prepared and processed under supervision*

Product	Inspection
Cured:	<i>Pounds</i>
Beef.....	150, 972, 303
Pork.....	3, 033, 861, 022
All other.....	24, 275, 649
Sausage.....	777, 605, 892
Canned:	
Beef.....	208, 538, 008
Pork.....	40, 399, 298
All other.....	5, 831, 992
Product passed for cooking:	
Beef.....	3, 010, 671
Pork.....	7, 267, 149
All other.....	2, 688
Pork to be eaten uncooked.....	50, 425, 316
Meat extract.....	109, 796
Lard.....	1, 845, 129, 153
Lard oil.....	9, 445, 129
Lard stearin.....	2, 669, 210
Compound and other substitutes for lard.....	472, 604, 084
Oleo stock and edible tallow.....	62, 831, 647
Oleo oil.....	117, 532, 413
Oleostearin.....	56, 864, 322
Oleomargarine.....	151, 990, 456
Miscellaneous.....	1, 939, 369, 038
Horse meat:	
Cured.....	12, 539, 846
Canned.....	595, 882
Miscellaneous.....	448, 125
Total.....	8, 974, 319, 089

NOTE.—The following quantities of meat and meat food products were condemned on reinspection and destroyed for food purposes on account of having become sour, tainted, unclean, rancid, or otherwise unwholesome: Beef, 1,923,362 pounds; pork, 7,237,385 pounds; mutton, 31,720 pounds; veal, 19,794 pounds; goat meat, 199 pounds; horse meat, 10,195 pounds; total 9,222,655 pounds.

Market inspection, to facilitate interstate delivery of meat and products, was conducted in 26 cities.

MEAT AND PRODUCTS CERTIFIED FOR EXPORT

During the fiscal year a total of 79,503 official meat-inspection certificates were issued to cover the exportation of the following products: Beef and beef products, 116,928,916 pounds; mutton and mutton products, 2,482,980 pounds; pork and pork products, 1,026,651,870 pounds; horse-meat products, 9,646,975 pounds; total, 1,155,710,741 pounds. There were also issued 4,661 certificates covering the exportation of 63,778,484 pounds of inedible animal products.

EXEMPTION FROM INSPECTION

The provisions of the meat-inspection law requiring inspection usually do not apply to animals slaughtered by a farmer on the farm or to retail butchers and dealers supplying their customers. The retail butchers and dealers, however, in order to ship meat and meat food products in interstate or foreign commerce, are required to obtain certificates of exemption. The number of such certificates outstanding at the close of the fiscal year was 964. During the year 893 certificates were canceled on account of dealers retiring from business or ceasing to make interstate shipments, change of address, insanitary conditions, violations of the meat-inspection regulations, and handling inspected meat only.

During the year 47,927 shipments were made by retail butchers and dealers holding certificates of exemption, as compared with 42,020 shipments during the fiscal year 1927. The shipments of the year covered products as shown in Table 11.

TABLE 11.—*Shipments by retail butchers and dealers under certificates of exemption*

Product	Car-casses	Pounds
Beef (361 quarters).....	90	46,081
Veal.....	24,917	2,079,774
Sheep.....	899	37,064
Swine.....	69	6,817
Beef, fresh.....	-----	1,752,303
Veal, fresh.....	-----	233,735
Mutton, fresh.....	-----	373,780
Pork, fresh.....	-----	193,244
Cured meats.....	-----	501,322
Lard.....	-----	28,545
Sausage.....	-----	69,051
Miscellaneous (scrapple, lard substitutes, suet, head-cheese, etc.).....	-----	87,079
Total.....	25,975	5,408,795

During the year 64,222 interstate shipments were made of meat and meat food products from animals slaughtered by farmers on the farm, as compared with 57,417 shipments made during the fiscal year 1927. The products composing these shipments are shown in Table 12.

TABLE 12.—*Shipments of farm-slaughtered products under exemption from inspection*

Product	Car-casses	Pounds
Beef (544 quarters).....	136	62,124
Veal.....	68,413	5,406,209
Sheep.....	5,751	173,792
Swine.....	3,061	327,892
Beef, fresh.....	-----	9,198
Veal, fresh.....	-----	14,150
Mutton, fresh.....	-----	688
Pork, fresh.....	-----	115,302
Cured meats.....	-----	402,450
Lard.....	-----	30,896
Sausage.....	-----	141,914
Miscellaneous (scrapple, pudding, etc.).....	-----	36,186
Total.....	77,361	6,720,801

INSPECTION OF IMPORTED MEAT

Table 13 shows the inspection of imported meat and meat food products for the fiscal year.

TABLE 13.—*Imported meat and meat food products inspected and passed*

Country of origin	Fresh and refrigerated meat		Cured and canned meat	Other meat products	Total weight
	Beef	Other classes			
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Argentina.....	-----	-----	18,079,797	1,673,566	19,753,363
Australia.....	70,340	204,695	1,288	101,998	378,321
Brazil.....	-----	-----	1,549,894	100,778	1,650,672
Canada.....	32,555,143	16,427,177	19,776,000	7,717,502	76,475,822
Uruguay.....	-----	-----	19,554,726	978,063	20,532,789
Other countries.....	5,542,638	2,248,675	4,227,775	1,530,728	13,549,816
Total.....	38,168,121	18,880,547	63,189,480	12,102,635	132,340,783

Table 14 shows the quantities of foreign meat and products excluded from the country because of unsoundness, presence of prohibited preservative, or other failure to comply with the regulations.

TABLE 14.—*Imported meat and meat food products condemned and refused entry*

Product	Condemned	Refused entry
	<i>Pounds</i>	<i>Pounds</i>
Beef.....	159, 148	40, 874
Veal.....	25	48
Mutton.....	246	1, 204
Pork.....	13, 281	19, 710
Total.....	172, 700	61, 836

IMPORTATION OF ANIMAL CASINGS

During the 7-month period from December to June foreign animal casings were admitted as follows: On certification, 9,861,440 pounds; on disinfection, 261,667 pounds; total, 10,123,107 pounds. Casings amounting to 35,006 pounds offered for importation were rejected and removed from the United States.

INSPECTIONS FOR OTHER BRANCHES OF THE GOVERNMENT

By request of other branches of the Government, reinspections of meat and meat food products were conducted, as shown in Table 15, to determine whether the articles remained wholesome and conformed to certain specifications.

TABLE 15.—*Inspections for other branches of Government*

Branch of Government	Passed	Rejected
	<i>Pounds</i>	<i>Pounds</i>
Navy Department.....	48, 794, 825	1, 090, 532
Marine Corps.....	1, 989, 780	21, 709
Department of Justice (Federal penitentiaries)...	1, 205, 929	48, 482
Veterans' Bureau.....	942, 850	80, 903
Department of Interior (Indian Affairs).....	580, 790	2, 035
Shipping Board.....	472, 073	9, 165
Public Health Service.....	376, 047	13, 511
War Department (Army Engineering Corps).....	313, 494	18, 654
Coast Guard.....	250, 335	1, 689
Total.....	54, 926, 123	1, 286, 680

MEAT-INSPECTION LABORATORIES

Analyses and examinations of meat and products were conducted in the meat-inspection laboratories situated in the several districts throughout the country.

The total number of samples examined was 43,564, of which 848 represented meat and meat food products offered for importation. Samples of 1,847 domestic and 179 imported products were found to be not in accordance with the regulations.

The samples examined included meats and meat food products, edible fats and oils, cereals, spices, curing materials, colors, denaturing oils, water supplies, and miscellaneous materials. Samples of sausage found to contain excessive added water constituted a substantial proportion of the violations. Samples of materials intended to be used as constituents of meat food products or in connection with the curing, preparation, or handling of meat and meat food products and found to be unfit for such use accounted for a large proportion of the remainder. No disposition to use prohibited dyes, chemicals, or preservatives was detected. Most of the samples of imported products not in conformity with the regulations were found to be misbranded.

Of the 1,785 samples of water, 306 were found to show evidence of pollution. All findings of pollution were followed by corrective action. Steady progress is being made toward the elimination of unsatisfactory conditions.

Further studies of dry rendering were carried out with particular reference to the behavior of the materials used for denaturing inedible fats. The results have disclosed the conditions under which the denaturing materials commonly used may be depended upon and permit the steady expansion of the dry-rendering process.

Samples of all brands of oleomargarine produced in inspected establishments were collected and examined for moisture content during the year. No evidence of any tendency to incorporate excessive quantities of water into this product was disclosed.

Methods for decharacterizing animal feeds and similar product so as to distinguish them from products intended for human food were worked out and their application administered. A method of cooking and denaturing

organs and parts condemned on account of parasitic infestation has been devised which makes it possible to permit the use of such product for fish feed.

LABELING MEAT AND MEAT FOOD PRODUCTS

There were approved during the year 14,956 labels and other markings for meat and meat food products, while 425 of such materials failed of approval owing to the fact that they did not conform to standards adopted in the interest of truthful and informative labeling.

The materials submitted for approval included a number designed for application to meat products prepared as feed for dogs, foxes, and other animals. Since the products were not denatured and possessed the characteristics of human food, it was necessary that the labeling be in harmony with the Federal statutes. This demanded the elimination of statements which were false or misleading in any respect, including extravagant claims of composition, food value, and other properties.

The increased demand for liver products and the labeling of these preparations presented numerous and varied new problems. The marketing of these articles as goose-liver products, or *pâte de foie gras*, through false labeling, as desired by some manufacturers, was prevented.

Requests to increase the moisture content of, or otherwise to adulterate, sausage by the use of tomatoes, tomato purée, potatoes, pickles, and considerable quantities of pimientos, paprika, Chili peppers, and onions were denied. These products must be labeled "imitation," in keeping with the regulations designed to protect the term "sausage" and to preclude fraud and deception. It was also required that the use of carrots and onions in the preparation of rendered beef fat be revealed to the consumer through appropriate declaration.

The addition of turmeric, paprika, and similar substances under the guise of seasoning to solutions which colored sausage in cooking was made contingent upon marking the sausage "artificially colored." The application of paprika and like substances to baked or roasted meat was prohibited on the ground that such practice conceals inferiority or otherwise creates deception which can not be effectively corrected by means of labeling.

In ruling upon the application of the term "barbecued" to meat, it was held that the term is applicable only to meat which has been prepared in contact with an open fire and assumed the characteristics of a baked or roasted product.

Cloth containers subjected to smoke previous to filling with meat were submitted for approval of the labels. It was ruled that the use of such containers would be deceptive unless the product has been actually subjected to smoke.

Some lard manufacturers who employ so-called dry-rendering equipment presented labels bearing the phrases "kettle-rendered lard" and "open-kettle-rendered lard" for application to product thus prepared. It was held that the equipment does not constitute a kettle within the general acceptance of this term, and therefore the proposed phrases were not approved.

PACKERS AND STOCKYARDS DIVISION

On July 1, 1927, by order of the Secretary, the Packers and Stockyards Administration was discontinued as a separate department unit, and the duties and personnel were transferred to the Bureau of Animal Industry. The work continued until December 31, 1927, under the supervision of John T. Caine, at which time, following his resignation, the organization was made a division of the bureau under A. W. Miller, chief.

This division conducts the work in connection with the enforcement of the packers and stockyards act. This act, which provides for the regulation of interstate and foreign commerce in livestock, livestock products, dairy products, poultry, poultry products, and eggs, involves supervision over the operations and practices of packers, stockyard companies, market agencies, and dealers, and rates and charges for stockyard services. The field work is conducted by 20 offices, with livestock market supervisors in charge. Three main lines of enforcement activities are carried on, embracing rates and registrations, audits and accounts, and trade practices.

FORMAL PROCEEDINGS

A summary of formal dockets, in which proceedings were instituted or cases were decided during the fiscal year involving violations of the pro-

visions of the act or the reasonableness of rates and charges for services furnished by stockyard companies, is given in the following statement:

FORMAL DOCKETS

Pending July 1, 1927.....	22
Instituted July 1, 1927, to June 30, 1928.....	78
Final action taken July 1, 1927, to June 30, 1928.....	82
Pending June 30, 1928.....	18

SUBJECT MATTER OF DOCKETS

Stockyard rates.....	8
Commission rates.....	8
Solvency.....	3
Trade practices.....	12
Bonds.....	67
Reparation.....	1
Failure to keep records.....	1

FORM OF ACTION

Cease and desist orders.....	38
Cease and desist orders and suspension.....	24
Order fixing rates.....	1
Order prescribing records to be kept.....	1
Dismissed.....	18

The larger number of dockets before the Secretary during the fiscal year were instituted against market agencies and dealers because of their failure to execute a bond to secure the performance of their obligations. A number of dockets were instituted because it appeared that the respondent had violated that provision of the act requiring stockyard owners and market agencies to establish, observe, and enforce just, reasonable, and nondiscriminatory regulations and practices. The stockyard and commission rate cases were instituted to determine whether rates charged by the stockyards or market agencies in question were just, reasonable, and nondiscriminatory. The details of each of the formal dockets are given in a separate publication, which may be had on request to the bureau.

CASES IN COURT PERTAINING TO THE
PACKERS AND STOCKYARDS ACT

On March 31, 1926, market agencies and dealers at the Oklahoma National Stockyards, respondents in Docket No. 136, brought a suit in equity to restrain the Secretary from enforcing his order to cease and desist from certain specified practices. On February 24,

1928, the case was argued orally before three judges in the United States court at Oklahoma City, Okla. No decision had been rendered at the close of the fiscal year.

The following cases in which parties were indicted for conspiracy to violate the packers and stockyards act came to trial in the United States district court at Chicago. On January 3, 1928, a dealer entered a plea of guilty and was fined \$500 in one case and \$2,000 in another. A former packing-company employee pleaded guilty and was fined \$50 and a former employee of a commission firm entered a plea of nolo contendere and a fine of \$500 was imposed. On January 9, 1928, a former employee of a market agency pleaded nolo contendere and was fined \$50. The court took into consideration the fact that the defendant had spent some time in jail previous to his plea.

On September 21, 1927, an order-buyer employee at the St. Joseph stockyards was indicted by the Federal grand jury at St. Joseph, Mo., a true bill being found on 11 counts alleging false entries in accounts and records of his employer. On February 11, 1928, the defendant pleaded guilty in the United States court to all counts and was fined \$11,000, \$10,500 thereof being suspended.

In the case in the Federal court at Omaha, involving an order of the Secretary in docket No. 143, regarding rates of commission for buying and selling livestock at the Omaha stockyards, briefs were filed with the special master appointed by the court by the Government and respondents during the fiscal year. The case is now pending, awaiting the report of the master.

STOCKYARDS

During the year four stockyards were posted as coming within the jurisdiction of the act and nine were released from jurisdiction. At the close of the year there were 75 stockyards under the jurisdiction of the act.

REGISTRATIONS

The status of the active registrants on June 30, 1928, is shown in Table 16.

TABLE 16.—*Number of commission men and other market agencies and dealers registered*

Class	Number of agencies handling—						Total
	All species	Cattle	Hogs	Sheep	Horses and mules	Other	
Market agencies:							
Commission men.....	732	5	2	11	17	22	789
Order buyers.....	116	76	26	7	1	15	241
Clearing agencies ¹							42
Miscellaneous ²							178
Total market agencies.....							1,250
Dealers:							
Buyers.....	775	559	213	111		311	1,969
Traders.....	85	572	193	38	14	48	950
Buyers and traders.....	103	82	18	4	3	41	251
Miscellaneous.....	23	15				12	50
Total dealers.....							3,220
Total registrants.....							4,470

¹ Does not include commission men and order buyers who render clearing services.² Does not include commission men and order buyers who render miscellaneous services.

During the year 172 market agencies and 640 dealers were registered, and 241 market agencies and 1,061 dealers were placed on the inactive list.

RATES AND CHARGES

The stockyard-rate study, as outlined in the last report of the Packers and Stockyards Administration, has been carried on at 10 markets. This work comprises the valuation of stockyard properties, a thorough analysis of the stockyards' financial operations, the competitive relationship of the various markets, and a study of the physical services rendered.

No material changes have been made in the rates and charges for stockyard services during the year. The rates for feed have been changed by most of the stockyard companies in accordance with the changes in market price. A number of tariffs were returned for modification in order that they might comply with the requirements of the act, and in several instances tariffs which had been submitted were withdrawn upon the suggestion of the bureau.

TRADE PRACTICES

Supervisors settled many matters informally, such as complaints as to price, quality, and weight of feed, shortages in count and loss of animals

in yards, errors in accounting, weighing, and docking, and the handling and sale of crippled livestock. They also assisted in the revision of tariffs, rules and regulations of market agencies and stockyard companies, and made investigations of complaints as to marketing conditions in general.

A case of some importance, involving the question of a boycott of a so-called independent market agency by a number of other market agencies and dealers, arose at one of the larger markets. A formal proceeding was instituted, and resulted in findings and a conclusion by the Secretary, in which the principles of free and open competition at public markets were emphatically stated and so-called boycott methods condemned.

Following the receipt of numerous complaints, investigations were made of certain packers' activities in the purchase of livestock at country points. A formal complaint was issued in one case, based on an alleged division of territory by two packers, and a hearing was held. The case was finally dismissed because the evidence failed to show a division of territory or any agreement to divide it.

BONDS

A survey of the bond situation was completed during the year at all except three markets. As a result bonds

were furnished by all market agencies and traders who continued in business. This was accomplished in most instances through informal action by the market supervisors. In some cases, however, the institution of formal proceedings by the Secretary was necessary.

Cases against a packer and packer buyer, respectively, involving the authority of the Secretary to require bonds of these classes of dealers progressed during the year to an oral argument before the Secretary, resulting in an order by him directing the respondents to procure bonds to cover their obligations on public stockyards.

SCALES AND WEIGHING

Considerable progress was made as a result of efforts to improve scales and conditions for weighing livestock at posted stockyards. Particular attention was given by weight supervisors to methods of weighing to insure accurate weights on all shipments of livestock consigned to such stockyards. The use of small scales for weighing small drafts was urged in order that light loads might not be weighed on scales designed and suitable only for weighing heavy loads. Small scales were installed at a number of yards. There was a marked increase in the general interest which is being taken in livestock scales and weighing, both on the part of stockyard companies and patrons of the

yards. This interest spread to shippers who use country livestock scales and the bureau cooperated with State agencies and others to improve the condition and reliability of such scales.

AUDITS AND ACCOUNTS

A number of audits and investigations of the books and records of stockyard companies, market agencies, and dealers were made by bureau accountants during the year. These involved matters of trade practices, financial condition, and general subjects in connection with the operations of market agencies, dealers, and order buyers, and stockyard companies. Practically the entire force of field auditors, together with a large group of temporary clerks, was engaged the greater portion of the year in the preparation of accounting and historical information and statistical data concerning the larger stockyards in the Middle West, for use in the valuation of stockyard properties and the study of stockyard rates.

Data compiled from annual reports received from packers, stockyard companies, and market agencies are shown in Tables 17 to 23. These reports cover business during the calendar year, with a few exceptions which are on the basis of the fiscal year, which does not correspond to the calendar year. These tables afford a perspective of the volume and character of the business conducted under the provisions of the act.

TABLE 17.—*Financial results of operations during year 1927 for 611 concerns subject to the provisions of the packers and stockyards act, grouped according to federally and nonfederally inspected slaughtering and nonslaughtering concerns*

Group	Number of concerns	Average net worth ¹	Net sales	Net gain
Federally inspected slaughterers.....	191	\$794,877.318	\$3,313,129,126 ¹	\$15,783,887
Nonfederally inspected slaughterers.....	215	33,068,109	177,778,238	3,010,917
Nonslaughterers.....	205	142,827,121	377,088,891	19,501,504
Total.....	611	970,772,548	3,867,996,255	38,296,308

¹ These figures represent the numerical average of the total net worth of reporting concerns at the beginning and end of their fiscal years.

In addition to the complete reports from 611 packing concerns, financial details, lacking in some respects, were received up to July 1 from 172 other

concerns for the year 1927. This group reported total net sales of \$12,266,201.60 and net profit of \$235,729.81.

TABLE 18.—*Comparison of the operations of meat-packing concerns subject to the packers and stockyards act, 1923-1927*

Item	1923, 494 concerns	1924, 525 concerns	1925, 514 concerns	1926, 580 concerns	1927, 611 concerns
Average net worth ¹	\$855, 023, 062	\$889, 919, 110	\$940, 268, 445	\$989, 916, 117	\$970, 772, 548
Total income.....	3, 109, 048, 602	3, 321, 964, 071	3, 816, 528, 294	3, 758, 972, 700	3, 877, 621, 354
Total expenses.....	3, 038, 180, 031	3, 245, 075, 725	3, 751, 970, 047	3, 699, 943, 922	3, 839, 325, 046
Net gain.....	70, 868, 571	76, 888, 346	64, 558, 247	59, 028, 778	38, 296, 308
Per cent of gain to net worth..	8. 28	8. 63	6. 87	5. 96	3. 94

¹ These figures represent the average of the total net worth of all reporting concerns at the beginning and end of their fiscal years.

STOCKYARDS POSTED UNDER THE PACKERS AND STOCKYARDS ACT

TABLE 19.—*Summary of consolidated balance sheets of 69 posted stockyards at close of year 1927*

Assets	Amount	Liabilities	Amount
Current.....	\$10, 842, 410	Current.....	\$2, 838, 359
Fixed.....	134, 088, 012	Other.....	34, 593, 533
Other.....	10, 943, 331	Capital and surplus.....	118, 441, 861
Total.....	155, 873, 753	Total.....	155, 873, 753

TABLE 20.—*Summary of consolidated profit-and-loss statements of 69 posted stockyards for year 1927*

Income:	
Yardage.....	\$11, 427, 722
Feed sales.....	11, 863, 743

Income—Continued.	
Loading and unloading..	\$1, 707, 836
Rent.....	2, 031, 978
Miscellaneous operations..	8, 077, 614
Gross operating income.....	35, 108, 893
Expenses:	
Salaries and wages.....	6, 278, 722
Cost of sales—feed.....	6, 465, 799
Depreciation.....	1, 883, 922
Taxes (excluding Federal income tax).....	1, 570, 149
Miscellaneous operating expenses.....	11, 022, 286
Total operating expenses.....	27, 220, 878
Net operating profit.....	7, 888, 015
Other income.....	640, 390
	8, 528, 405
Other deductions.....	1, 699, 396
Net profit.....	6, 829, 009

TABLE 21.—*Summary of reports from stockyard companies subject to the packers and stockyards act, 1924-1927*

Item	1924, 58 concerns	1925, 62 concerns	1926, 65 concerns	1927, 69 concerns
Total average net worth.....	\$113, 225, 257	\$115, 858, 752	\$116, 327, 131	\$118, 071, 659
Gross income.....	30, 793, 413	37, 406, 167	36, 086, 366	35, 108, 893
Net gain.....	7, 440, 867	6, 672, 983	6, 561, 847	6, 829, 009
Per cent of gain to net worth.....	6. 57	5. 76	5. 64	5. 78

LIVESTOCK COMMISSION AGENCIES

TABLE 22.—*Number and class of market agencies reporting, 1927*

Class	Number of agencies reporting—	
	For the full year	For part of the year
Old-line agencies.....	640	44
Cooperative agencies.....	28	—
Horse and mule agencies.....	14	3
Total.....	682	47

TABLE 23.—*Summary of consolidated operating statement of livestock commission agencies*

Item	1926, 683 agencies	1927, 729 agencies
Total commissions earned.....	\$23, 110, 922	\$23, 017, 604
Operating expenses (exclusive of owners' salaries).....	15, 966, 507	16, 186, 814
Net operating profit.....	7, 144, 415	6, 830, 790
Other income.....	978, 048	1, 267, 499
Other expenses.....	62, 177	35, 351
Return to owners.....	8, 060, 286	8, 062, 938

TRADERS AND ORDER BUYERS

Approximately 350 registered traders and order buyers submitted reports covering operations for the calendar year 1927. This represents about one-fourth of the total number of such registrants. Failure to receive reports from others was due largely to the attitude of certain traders' organizations which questioned the authority of the Secretary to require reports from dealers in the form prescribed. Conferences were held with representatives of these organizations and their counsel. At the close of the fiscal year it seemed that it would be necessary to take formal action in some cases in order to determine the legal issue.

PATHOLOGICAL DIVISION

Under the direction of John S. Buckley, chief, the Pathological Division has followed its usual line of scientific investigation of the diseases of domestic animals and birds, the poisoning of livestock by plants, and the examination of viruses, serums, and other remedies used in the treatment or prevention of diseases of farm animals.

DIAGNOSIS AND CONTROL OF DISEASES

RABIES

One hundred and forty-two suspected cases of rabies were received and subjected to laboratory examination. These included 70 positive cases in dogs, of which 37 were from the District of Columbia. Besides these, 13 cats were received, 5 of which proved to be affected with rabies, while 8 were negative for that disease. Ten specimens from rabid cows were received and four suspected cases that proved to be negative. Specimens from four horses were presented, three of which were found to present evidence of rabies. The remaining cases were negative or in such poor condition that no satisfactory examination could be made. A total of 81 persons, mostly dog and cat owners or their children, were bitten or scratched by affected animals.

INVESTIGATIONS OF DISEASES RESEMBLING FOOT-AND-MOUTH DISEASE

Several field investigations were made of diseases of cattle reported as possibly being foot-and-mouth disease, but none proved to be this dreaded malady. Likewise animal-inoculation experiments made at the bureau experiment station at Bethesda with ma-

terials from suspected animals from different sections of the country resulted negatively.

SWINE ERYSIPELAS

During the year specimen tissues from a hog which had died rather suddenly without any manifest symptoms were received from a practicing veterinarian in Virginia, who further reported that this was the third animal lost within a period of a few days in a herd of 500 purebreds. The herd had been immunized against cholera during the previous fall. *Erysipelathrix rhusiopathiae* was isolated in pure culture from the specimens of spleen and mesenteric lymph gland. The organism was found pathogenic for mice, rabbits, and pigeons, but not for hogs. In order to eliminate definitely the virus of hog cholera as a possible cause for the outbreak, two pigs were inoculated with a fresh saline suspension of some of the specimen tissues submitted. No temperature or general reaction resulted from this inoculation, and after being held for observation for 20 days the animals were inoculated with filtered blood from a hog suffering from hog cholera. Both animals succumbed, and at autopsy revealed typical lesions of cholera.

GLANDERS

Cooperative work for the control and eradication of glanders in the various States was continued. The complement-fixation test was applied to 139 samples of serum from animals suspected of being affected with or exposed to the disease, 11 of which gave positive reactions.

DOURINE

In the course of the campaign for the control and eradication of dourine 14,272 samples of blood serum from horses in districts where dourine is present or suspected were subjected to the complement-fixation test, and 451, or approximately 3.2 per cent, gave positive reactions.

TESTING ANIMALS FOR IMPORT

Blood serum from 27 horses and donkeys offered for import was subjected to the complement-fixation test for glanders and trypanosomiasis before the animals were admitted. The same test was also applied to 12 camels for trypanosomiasis before admission. One animal giving a positive reaction to the test was destroyed.

ANIMALS FROM THE NATIONAL ZOOLOGICAL PARK

Fifty-nine animals from the National Zoological Park were autopsied in an effort to determine the cause of death, which was established in 46 cases.

TESTS WITH JOHNNIN

Intravenous and intradermic tests were applied with johnnin used in the diagnosis of paratuberculosis. This product is at present being used experimentally, fair results having been obtained after application of this test to a number of dairy herds.

POULTRY-DISEASE INVESTIGATIONS

Numerous pathological specimens were received from various sections of the country, among which were observed such diseases as chicken pox, fowl cholera, roup, infectious bronchitis, tuberculosis, coccidiosis, bacillary white diarrhea, blackhead (in turkeys), tumors, and other abnormal conditions.

The agglutination test for the detection of *Salmonella pullorum* infection of fowls has been applied to a large number of birds in an effort to eradicate this infection from poultry farms from which they originated.

Further investigations of poultry diseases were briefly as follows: Examination of poultry-disease specimens, examination of cultures of poultry pathogens, serological tests, and research in avian pathology.

SWINE PNEUMONIA

Hogs arriving during the year at a number of slaughtering establishments were reported as showing some temperature, depression, increased respiration, cough, and other symptoms indicating a lung involvement. Autopsy findings in these cases showed the lesions to be confined to the lungs, in which the pneumonia is usually of a catarrhal type varying in extent in the different cases. Lung worms were found in only a limited number of cases. Bacteriological examinations in these cases did not clear up the matter from an etiological standpoint.

The disease appears to have been a type of the so-called "flu" or shipping fever, brought about by influences incident to shipping the animals long distances, such as exposure, crowding, rough handling, and change of feed.

RESEARCH ON DISEASE PROBLEMS

"SEEDY BELLIES" OF SWINE

A condition commonly referred to at slaughtering establishments as "seedy bellies" has long been observed in hogs. Most pregnant sows show the condition more or less. It occurs in the subcutaneous abdominal tissues and is of economic importance because of the trimming necessary in many of the animals affected. In well-defined cases the necessary trimming amounts to about 4 pounds per animal.

A histological examination of a number of specimens so affected indicated that the peculiar coloration of the tissues is due to rather heavy deposits of a brownish pigment in the mammary glands, remains of the mammary glands, and related tissues. The examinations gave no clue to the possible cause of the pigmentation.

PATHOLOGICAL CHANGES IN BOVINE LIVERS

Histological studies have been made from time to time of certain types of lesions in bovine livers, involving the disposition of such livers from a meat-inspection standpoint.

VACCINATION OF DOGS AGAINST RABIES

Experimental work on the prophylactic vaccination of dogs against rabies with particular reference to the efficacy of a vaccine rendered avirulent or killed by carbolic acid was continued. Vaccinated dogs were tested for immunity by various methods. Vaccination gave little protection against the intraocular infection of rabies street virus contained in the brain tissues of rabid animals. In a limited experiment a vaccinated dog later injected intramuscularly with an emulsion of the salivary glands of a rabid dog survived, while a control dog injected with the same material died of rabies. In later experiments, however, this method of exposure to street virus failed to cause the disease in a sufficient number of dogs to be of any value in interpreting results. Vaccinated dogs were also exposed to the bites of rabid dogs, and, although a number of control dogs failed to develop the disease, in several cases the vaccine appeared to have some protective value.

Steps have been taken to test the efficacy of vaccines rendered avirulent by formalin.

Tests made at various times on samples of rabies vaccines prepared for the prophylactic vaccination of dogs by the various biological houses failed in every case to show the presence of active virus in these products.

ANAPLASMOSIS OF CATTLE

For several years lately a malignant febrile disease of cattle associated with hemorrhagic lesions of the heart, pericardium, and pleura and rather high mortality has existed in a Texas-fever-tick-free county on the east coast of Florida. Local veterinarians had made a tentative diagnosis of hemorrhagic septicemia, but found the aggressive treatment ineffective. Likewise, all medicinal agents tried were without avail. An investigation of the affection resulted in the discovery of a pure infection of anaplasmosis, *A. marginale*, unmixed with the Texas-fever piropiasm. The anaplasma found in the Florida cattle appeared to be very similar to if not identical with the *A. marginale* occurring in South America and the Old World. The vector of anaplasmosis in this country has not been definitely determined although biting flies, mosquitoes, and sucking lice are being investigated. A single experiment with *Tabanus atratus* gave negative results. In other countries the following ticks are known to be capable of transmitting the infection: *Margaropus australis*, *M. decoloratus*, *Rhipicephalus simus*, *Ixodes ricinus*, and *M. microphilus*.

The incubation period following experimental inoculation was found to be from 16 to 32 days. The sequence of reactions following inoculation was first a parasitic attack followed shortly by a thermic reaction and then anemia and regeneration. Marked parasitic and febrile reactions as well as pronounced anemia were induced in experimental cattle at the bureau's experiment station, Bethesda, Md., but no fatal results ensued. Complete recovery occurred in about three or four months.

The chief distinguishing features between this disease and Texas fever are the absence of ticks and of hemoglobinuria in the former and their presence in the latter.

Experiments with the so-called incubation virus of Sergeant for immunizing cattle were carried out on a limited scale in Florida, and results, while not wholly satisfactory, were promising. For treatment, large, intravenous doses (100 to 200 grains) of sodium caco-

dylate gave better results than any other medicament tried. Thus far anaplasmosis has been positively diagnosed in cattle in the following States: Florida, Louisiana, Texas, Oklahoma, Kansas, Nevada, and California.

STUDIES OF WARTY GROWTHS OF CATTLE

Investigations pertaining to the cause of warty growths of cattle are still under way and will probably be completed during the coming year.

Experimental warty growths have been produced in a number of bovine animals by intradermic inoculations with emulsions of wart specimens of bovine origin and also with filtrates from a number of the same specimens. The filtrates were made by passing the fluids from the emulsified wart material through fine, bacteria-retaining filters. In a few instances second generations of experimental warts have been produced by reinoculations of bovine animals.

Warty growths varying in size and extent in the different animals have been produced in a large proportion of bovine animals, mostly calves, thus far inoculated. Bacteriological studies have given negative results. The cause of such growths is probably of the nature of a filterable virus.

TESTING BIOLOGICAL PRODUCTS

Cooperative work with the Division of Virus-Serum Control on the testing of biological products and investigations into methods of their preparation was continued. Of 104 samples of biological products prepared under United States veterinary licenses, 17 were found unsatisfactory because of bacterial contamination, lack of potency, or presence of injurious substances. Of 168 cultures of organisms intended for use in the preparation of various biologics, 27 were rejected as unsuitable on account of not being true to type, contamination, or non-viability.

HEMORRHAGIC-SEPTICEMIA AGGRESSIN

Investigations on methods of preparing hemorrhagic-septicemia aggrassin were made. The discovery of a batch of commercial aggrassin contaminated with *Clostridium botulinum* toxin, mentioned in last year's report, led to experimental work to determine the effect of 0.5 per cent phenol on the development of *C. botulinum* toxin in crude aggrassin. Although toxin failed to develop in both nonphenolized

and phenolized samples of aggressin, it was found that 0.5 per cent phenol failed to prevent the development of *C. botulinum* toxin in meat-piece media under anaerobic conditions.

INVESTIGATION OF STOCK-POISONING PLANTS

During the year the investigations of stock-poisoning plants were largely in continuance of those of past years and under the same general plan of work. The Salina Experiment Station was kept open from June 1 to September 30, and most of the strictly experimental work was carried on at that place, while the laboratory and summarizing work was to a large extent conducted in the office at Washington, D. C.

Following are brief statements in regard to the work on individual plants which gave definite results during the year:

Astragalus bigelovii.—*A. bigelovii*, which has been considered one of the loco plants, was fed in large quantities without producing poisonous effects. While further work is desirable in corroboration of that already done, it seems highly probable that the plant is not poisonous to livestock.

Cicuta occidentalis.—Some experimental work was done by feeding second-growth shoots of *C. occidentalis*, which indicated that these shoots were not poisonous.

Kalmia latifolia, "mountain laurel".—There is no question concerning the poisonous properties of mountain laurel, but it is important to determine definitely the toxic dosage of the plant.

Ledum glandulosum.—The work on this "laurel" has indicated that, as a poisonous plant, it is not important.

Lonicera japonica.—A little work was done in Washington on this plant, known as the Japanese honeysuckle, because of the supposed poisoning of beavers. The work corroborated some former work in the bureau to the effect that the plant was not poisonous.

Rhododendron albiflorum.—The work with this "laurel" was on sheep, because it had been supposed to be the cause of range poisoning of these animals. The results indicate that the plant is not very poisonous, and consequently is not a source of great danger.

Senecio integerrimus.—Because of a request for investigation of the "walking disease" of horses, *S. integerrimus* has been used in feeding experiments. It had been presumed that the "walking disease" might be caused by the

eating of the lupines. It now seems probable that this *Senecio* is the cause of the trouble, and that it is liable to produce poisoning in horses and cattle, but not in sheep. Further work will be necessary.

TOXICOLOGICAL INVESTIGATIONS

During the year chemical and toxicological investigations of animal diseases have been continued. Considerable progress has been made in the solution of problems arising from plant poisoning, as follows:

Eupatorium urticaefolium.—The toxic constituent of *E. urticaefolium* that is responsible for milk sickness and trembles has been isolated, purified, and studied chemically and pharmacologically. Three papers dealing with various aspects of the subject were prepared for publication in scientific journals.

Aplopappus heterophyllus.—Work on available material of *A. heterophyllus* has been continued. Attempts to prepare a larger quantity of the toxic substance so as to permit a chemical and toxicological study of it were made, but larger supplies of the plant are needed.

Lupines.—Alkaloids from the following species have been isolated during the past year: *Perennis*, *laxiflorus*, *caudatus*, *latifolius*, and *saxosus*. Chemical studies of these and other lupine alkaloids have been made.

Loco.—Chemical study of the active principle of *Oxytropis lambertii* has been continued. A study has also been made of a related plant, *O. albiflorus*, which shows it to be capable of causing locoism in cats.

BRANCH LABORATORIES

CHICAGO

The work at the branch pathological laboratory at Chicago has been increasing since it was established, in 1906. During the past year more pathological specimens from food-producing animals were received and examined than in any previous year.

A number of cattle livers which were slightly enlarged, with thickened borders, and intensely yellow in color, sometimes mottled with accumulations of white, fibrous, connective tissue, were submitted for examination. In most instances these livers were from steers which came from the southwestern ranges. Examination

showed the livers to contain an excessive amount of fat, in which were deposited large accumulations of lutein, which gave the livers their intensely yellow color. It is believed that the condition is of dietetic origin.

As in former years, a number of specimens mounted under watch glasses were prepared for department exhibit purposes.

DENVER

During the year 1,343 specimens were received at the laboratory for examination. In addition, extensive field investigations of anaplasmosis of cattle, horses, dogs, and rabbits were conducted:

OMAHA

More than a hundred diseased chickens were received for study from various sources. They furnished the usual variety of ailments: Worm infestation, intestinal coccidiosis, and flagellosis, each of these groups of infestation showing at times secondary bacterial infection. Such infections were caused, in order of prominence, by *Salmonella pullorum*, *Pasteurella avicida*, and *Eberthella sanguinaria*, and other organisms of less importance. This reference to the prominence of these three bacillary invaders does not, however, disqualify tuberculosis from first place in importance among diseases of adult fowls.

The total number of specimens for the year was 857, of which 672 were reactor specimens. The remaining 185 specimens were suspected of being caused by diseases other than tuberculosis. Of the year's total of reactors 36 were positive for tuberculosis and the remainder negative.

TICK ERADICATING DIVISION

The work of eliminating Texas or tick fever in cattle from the United States through the eradication of the tick which transmits this disease was continued under the direction of R. A. Ramsay, chief, in cooperation with

cattle owners and State and county officials in the infested Southern States.

PERSONNEL AND POLICIES

The field activities in this project were continued under the direction of nine field stations, which at the close of the fiscal year had a total field force of 240 veterinarians and other employees working in cooperation with 621 State inspectors and 122 county inspectors.

Under the supervision of these co-operating forces 17,627,260 inspections or dippings of cattle were conducted and more than 15,000 dipping vats were used in these official dippings. The plan of giving special attention to the complete elimination of the tick in areas which have been released from Federal quarantine, but in which a small amount of infestation remains, was continued. The bureau has also continued to urge, as the most economical and satisfactory policy, that areas in which systematic work is to be undertaken be carefully prepared and that the cooperative effort there be so concentrated as to give reasonable assurance that the area will be made ready for release from quarantine with one season's work.

RESULTS FOLLOWING THE YEAR'S ACTIVITIES

During the fiscal year the following areas were released from Federal quarantine as a result of the tick-eradication work conducted therein: One county in Alabama; 5 counties, the remainders of 2 counties, and parts of 2 counties in Arkansas; 2 counties and the remainders of 3 counties in Florida; 1 county and the remainder of 1 county in South Carolina; 8 counties and part of 1 county in Texas; and 1 county in Virginia. During the same period 1 parish in Louisiana was requarantined.

Table 24 shows the progress made in tick eradication since its beginning in 1906, and gives the status of the work at the close of the fiscal year 1928.

TABLE 24.—*Tick-eradication results, July 1, 1906, to June 30, 1928*

States	Counties quarantined		Counties released to June 30, 1928	Released counties tick-free					
	July 1, 1906	June 30, 1928		Nov. 1, 1922	Nov. 1, 1923	Nov. 1, 1924	Nov. 1, 1925	Nov. 1, 1926	Nov. 1, 1927
Alabama.....	67	4	63	15	26	41	49	49	57
Arkansas.....	75	22	53	16	21	34	31	41	44
California.....	15	0	15	15	15	15	15	15	15
Florida.....	67	49	18	3	3	1	7	12	14
Georgia.....	158	0	158	101	119	138	149	151	153
Kentucky.....	2	0	2	2	2	2	2	2	2
Louisiana.....	64	43	21	3	3	4	4	11	4
Mississippi.....	82	23	59	37	47	54	47	47	46
Missouri.....	4	0	4	4	4	4	4	4	4
North Carolina.....	73	0	73	40	46	53	65	73	71
Oklahoma.....	61	4	57	35	47	49	52	55	54
South Carolina.....	46	0	46	29	35	36	40	40	44
Texas.....	198	80	118	44	49	56	69	72	77
Virginia.....	31	0	31	(1)	(1)	(1)	25	27	26
Tennessee.....	42	0	42	41	41	42	42	42	42
Total.....	985	225	760	385	458	529	601	641	653

¹ Inactive Nov. 1, 1922 to Nov. 1, 1924.

MOVEMENTS FROM QUARANTINED AREAS

It is generally believed that the discontinuance of the interstate shipment of ticky or so-called "southern cattle," in cars so placarded, for immediate slaughter, made effective during the year, will prove of decided value in stimulating additional interest in tick eradication throughout the quarantined area. The shipment of southern cattle to market centers in the free area, which has long been looked upon as dangerous, was authorized by special provision in an act of Congress passed in 1884 before the cattle tick was incriminated as the carrier of Texas or tick fever. This special provision in the 1884 law was repealed by the act of Congress commonly referred to as the Crisp bill, approved June 28, 1926, the provisions of which became effective May 1, 1928, and which prohibit the interstate shipment of all ticky animals. The prediction made by a few when the passage of this law was under consideration that its provisions would prove ruinous to the quarantined area has not materialized, and while this law has been in force but a short time it is apparent that the industry is rapidly adjusting itself to the new conditions and that cattle owners of the quarantined area are finding it not only practicable but profitable to ship tick-free cattle only.

During the 10 months of the year prior to May 1, 1928, when the interstate shipment of southern cattle was permitted, 316,007 cattle of this class

were shipped to market centers for immediate slaughter.

In the supervision of the treatment of cattle for shipment from the quarantined area for purposes other than slaughter 178,893 head were inspected, or dipped and inspected, in the field, for which 2,765 certificates were issued authorizing their movement as non-infectious.

WORK IN FLOOD AREAS

In the last annual report mention was made of the conditions brought about by the Mississippi flood, which had forced the removal of all livestock from large sections of the quarantined area and had destroyed the ticks infesting the inundated lands. The bureau at that time urged that advantage be taken of this opportunity to accomplish tick eradication by restocking these areas with tick-free animals, and, appreciating the depleted resources of these flooded sections, the Secretary of Agriculture made available funds with which to defray all expenses necessary in carrying out the plan. Because of demoralized conditions and lack of interest on the part of cattle owners, only a relatively small section of the flooded area found it feasible to take advantage of this offer. The plan, however, has proved to be entirely successful where tried, and by its application the Louisiana parishes of West Baton Rouge, Assumption, and part of Ascension have become tick free as a result of the flood and subsequent work.

MOTION PICTURES HELP TICK ERADICATION

The motion picture as a factor in molding favorable sentiment for tick eradication has continued to prove its value, and in several sections where indifference or opposition to the project were reported it has produced good results by giving those who opposed the work a better understanding of the methods necessary for success and the benefits that may be expected to follow. With the two portable motion-picture outfits, audiences aggregating 37,750 persons were reached at 276 exhibitions given in the rural districts of the tick-infested sections of Florida, Mississippi, and Texas.

TUBERCULOSIS ERADICATION DIVISION

The cooperative work of tuberculosis eradication suffered a severe loss during the year in the death of its chief, John A. Kiernan, who died December 13, 1927. Doctor Kiernan had been the chief of the division since its organization, in May, 1917. The skill with which the work was organized and the marked progress made were attributable largely to his energy. Alexander E. Wight, who was assistant to Doctor Kiernan from the time of the division's organization, succeeded him as chief on February 1, 1928.

The general progress of the work during the year throughout the 48 States and the Territories of Hawaii and Alaska has been very satisfactory. There was a marked increase in the number of cattle tested and in the growth of the area eradication work. Much progress was made also in systematizing plans for the control of avian tuberculosis. The year's efforts in salvaging reactor cattle also showed satisfactory results. Owing to higher prices of beef cattle, the greatest average salvage ever received was paid for the animals which reacted to the tuberculin test.

The bureau's force engaged in tuberculosis eradication averaged 212 veterinarians, who were under the supervision of inspectors in charge of 44 field stations. The respective States had under the jurisdiction of their livestock sanitary officials an average of 360 veterinarians. These figures include a limited number employed by several municipalities.

The respective counties cooperating with the officials of the States and the bureau employed an average of 351 veterinary inspectors on full time. Thus there was a total of 923 veterinarians engaged in the work regularly

throughout the year, an increase of approximately 75 full-time employees over the preceding year. The increase was divided about evenly between State and county agencies.

Both State and Federal appropriations for the work were greater than during the preceding year, the increase being principally for indemnity purposes. The Federal appropriation was \$5,964,000, of which \$1,086,000 was allotted for operating expenses and \$4,878,000 for paying indemnity to owners for cattle condemned as a result of the test. These figures indicate a net increase of approximately \$1,200,000 for all purposes over the year 1927. The combined State appropriations were more than \$13,000,000. These enlarged funds resulted in a considerable increase in the number of cattle tested, being more than 16 per cent over the preceding year.

The plans for the work now include: (1) The eradication of tuberculosis under the accredited-herd plan; (2) the area plan; (3) the eradication of the disease from swine; (4) investigations relative to interstate shipments, and (5) tuberculosis in fowls. Recently there was added work looking to the control of Johne's disease (paratuberculosis). The act of Congress authorizing appropriations for the fiscal year 1928 included legislation authorizing that work to be conducted in a manner similar to that of eradicating tuberculosis.

A number of herds in several States were tested during the year by the use of either avian tuberculin or johnin, and indemnity was paid for animals which reacted and were slaughtered. The tests conducted indicate that much more work must be done to develop a standardized, diagnostic agent before the johnin test will become entirely practicable for field purposes.

A new survey relative to the interest of towns and cities in tuberculin testing, as a part of milk ordinances, was conducted in cooperation with the Bureau of Dairy Industry and the United States Public Health Service. It showed an increase from the 1,249 towns and cities reported under a previous survey conducted in 1926 to a new total of 2,112. Of these, 1,502 require the tuberculin test alone, 55 require the tuberculin test and pasteurization, while 555 permit the option of either the tuberculin test or pasteurization. It is apparent that health officers throughout the country have a full appreciation of the value of the tuberculin test.

Another survey conducted relates to the biennial checking up of the estimated extent of the disease. These surveys commenced in 1922, and the fourth one, completed on May 1, 1928, indicated a further reduction of the disease. The figures for the four surveys are as follows: 1922, 4 per cent of cattle infected; 1924, 3.3 per cent; 1926, 2.8 per cent; and 1928, 2 per cent. A study of this survey affords highly significant facts. For instance, of the 3,072 counties in the United States, only 139 now contain more than 7 per cent of infection in their cattle.

ACCREDITED TUBERCULOSIS-FREE HERDS

Although major attention was given to the area project, tuberculin testing under the accredited-herd plan showed marked progress in practically all States. At the conclusion of the year there were listed, as fully accredited, 169,356 herds, an increase of 38,880 over the previous year. Comparative figures showing progress are given in Table 25.

The total numbers of herds and cattle under supervision at the end of the year were 2,290,732 and 21,418,977, respectively. On the basis of the latest census figures of cattle on farms, this total indicates approximately 35 per

cent of the entire cattle population of the United States as being under supervision for the eradication of tuberculosis. It is also noteworthy that 17 States report more than 50 per cent of their cattle population as being under such supervision. These States are led by North Carolina, which reports 96.3 per cent of its cattle as having been tuberculin tested, closely followed by Maine, with 93.6 per cent. As an indication of the continued interest in the work, there was at the end of the year a waiting list of more than 345,000 herds containing 3,250,000 cattle.

Marked increase in the herds under supervision as the result of accredited-herd work and area work necessitated the tuberculin testing of 1,048,277 herds, including 11,281,490 cattle. These figures for testing include those cattle tested for interstate shipment. From these were removed 262,113 reactors, or 2.3 per cent, which is the smallest percentage since the beginning of the work. It is noteworthy, as shown in Table 25, that since 1917 more than 1,550,000 reactors have been removed from the cattle herds of the Nation without any economic disturbance or creating any shortage of the necessary milk supply.

TABLE 25.—*Progress of tuberculin testing under accredited-herd and area plans, 1917-1928*

Year ended June 30—	Cattle tested					Modified accredited counties	Herds accredited ¹	Herds passed one test ¹	Herds under supervision ¹
	Accred- ited- herd plan	Area plan	Total	Reactors found	Per cent of reactors				
	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>		<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
1917.....	20, 101		20, 101	645	3.2				
1918.....	134, 143		134, 143	6, 544	4.9		204	883	
1919.....	329, 878		329, 878	13, 528	4.1		578	5, 652	
1920.....	700, 670		700, 670	28, 709	4.1		2, 588	10, 064	
1921.....	1, 366, 358		1, 366, 358	53, 768	3.9		4, 831	33, 215	71, 806
1922.....	1, 722, 209	2 662, 027	2, 384, 236	82, 569	3.5		8, 015	111, 719	140, 376
1923.....	1, 695, 662	1, 765, 187	3, 460, 849	113, 844	3.3		12, 310	150, 748	187, 915
1924.....	1, 865, 863	3, 446, 501	5, 312, 364	171, 559	3.2		38	19, 747	216, 737
1925.....	2, 008, 526	4, 991, 502	7, 000, 028	214, 491	3.1		51	24, 110	392, 740
1926.....	1, 989, 048	6, 661, 732	8, 650, 780	323, 084	3.7		109	24, 009	382, 674
1927.....	2, 522, 791	7, 177, 385	9, 700, 176	285, 361	2.9		149	34, 084	435, 840
1928.....	2, 589, 844	8, 691, 646	11, 281, 490	262, 113	2.3		180	229, 086	261, 148
Total....	16, 945, 093	33, 395, 980	50, 341, 073	1, 556, 215	3.1	³ 527	169, 356	1, 961, 113	2, 290, 732

¹ The figures in these columns represent net increases at the close of each year.

² Testing during 6 months.

³ Not including parts of 2 counties and 20 towns.

Accredited practicing veterinarians continued their cooperation, their work showing an increase of more than 22 per cent over 1927 in the volume of testing

conducted. This class of veterinarians tested during the year 75,867 herds, containing more than 1,142,000 cattle, at the expense of the livestock owners.

ERADICATION OF TUBERCULOSIS FROM AREAS

The area work has continued to grow, and the efficiency of the plan was further demonstrated. Rapid progress was made in many States. Approximately 77 per cent of the total cattle tested in the work of eradication were tested under this plan. At the conclusion of the fiscal year 1,119 counties and the District of Columbia had engaged in area work. This is an increase of 166 counties, or approximately 17 per cent, over the number for the preceding year.

Financial interest in the work, as indicated by county appropriations, was continued. These expenditures for the year were approximately \$1,496,730, an increase of more than

\$289,000. Modified accredited counties increased in number under the plan in effect between the Department of Agriculture and the respective States. At the conclusion of the year there were 527 modified accredited counties, not including 21 towns and the parts of two other counties. This is in comparison with 347 such areas at the end of 1927. Field reports indicate that at the completion of the year 17.2 per cent of the total counties in the United States were in the modified accredited class, and that including the modified counties 36 per cent of the entire number of counties in the United States were engaged in the extirpation of the disease from their livestock. Table 26 indicates the status of the area work on June 30, 1928.

TABLE 26.—*Status of tuberculosis eradication from county areas at close of fiscal year 1928*

State	Counties completing one or more tests of all cattle ¹	Counties intensively engaged in testing	Total counties engaged ¹	Modified accredited counties	Cattle tested during year
Alabama.....	0	3	3	0	(²)
Arizona.....	0	14	14	0	43,498
Arkansas.....	0	1	1	0	5,788
California.....	2	4	6	2	86,601
Colorado.....	0	3	3	0	7,365
Connecticut.....	0	4	4	0	53,787
Delaware.....	1	0	1	0	-----
District of Columbia.....	1	0	1	0	750
Florida.....	3	0	3	0	2,184
Georgia.....	4	3	7	2	18,595
Idaho.....	19	15	34	19	88,297
Illinois.....	17	58	75	17	941,109
Indiana.....	47	20	67	40	324,424
Iowa.....	50	10	60	43	893,865
Kansas.....	35	2	37	35	242,892
Kentucky.....	43	9	52	9	84,813
Maine.....	12	4	16	12	106,549
Maryland.....	3	9	12	0	107,940
Michigan.....	63	7	70	55	540,935
Minnesota.....	26	0	26	15	1,084,215
Mississippi.....	3	2	5	2	31,860
Missouri.....	6	4	10	6	58,764
Montana.....	³ 8	³ 2	10	³ 7	73,254
Nebraska.....	38	2	40	29	366,744
Nevada.....	0	13	13	0	16,674
New Hampshire.....	1	4	5	1	9,419
New Mexico.....	0	22	22	0	15,047
New York.....	17	31	48	7	597,843
North Carolina.....	93	7	100	93	82,163
North Dakota.....	26	13	39	26	145,141
Ohio.....	29	25	54	20	409,713
Oregon.....	10	16	26	4	137,515
Pennsylvania.....	17	41	58	14	529,219
South Carolina.....	7	2	9	7	48,864
South Dakota.....	5	0	5	4	66,941
Tennessee.....	4	7	11	4	79,387
Utah.....	2	26	28	1	87,681
Vermont.....	(⁴)	7	7	(⁴)	32,701
Virginia.....	12	7	19	11	51,573
Washington.....	³ 7	³ 27	35	³ 4	178,786
West Virginia.....	13	7	20	11	59,354
Wisconsin.....	55	8	63	27	979,396
Total.....	³ 679	³ 439	1,120	527	8,691,646

¹ Including District of Columbia.² Testing included in accredited-herd work.³ Not including part of 1 county.⁴ Not including 21 towns.

STATISTICS OF SLAUGHTER AND INDEMNITY

Continued attention was given the marketing of reactor cattle. The large number of such animals thrown on to the markets makes this an important phase of the cooperative work. It is noteworthy, as indicated by the average salvage per head, shown in Table 27, that these efforts have been fruitful, though aided by a high aver-

age market price for beef cattle throughout the year. Visits were made by State and bureau workers to public stockyards, packing houses, commission agencies, and others, wherever it was suspected that better prices might be obtained. The average salvage for 1928, as will be noted by Table 27, was \$40.01, an increase of \$9.32 over the amount during the preceding year.

TABLE 27.—*Cattle slaughtered, appraised value, indemnity allowed, and salvage realized in work of tuberculosis eradication, fiscal year 1928*

State	Cattle slaugh- tered	Average appraisal per head	State indemnity	Federal indemnity	Average State indem- nity per head	Average Federal indem- nity per head	Average salvage per head
	<i>Number</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>
Alaska.....	18	175.00	1,650.00	450.00	91.67	25.00	-----
Arizona.....	543	124.77	13,791.41	13,791.41	25.40	25.40	28.40
Colorado.....	291	103.70	6,018.65	6,018.65	20.68	20.68	40.67
Connecticut.....	9,591	97.22	408,582.85	187,622.60	42.60	19.56	32.45
Delaware.....	1,296	80.17	34,391.25	22,817.26	26.54	17.61	27.35
District of Columbia.....	1	100.00		21.17		21.17	35.00
Florida.....	320	40.59	5,205.57	2,946.39	16.27	9.21	13.00
Georgia.....	83	69.16	1,234.00	1,234.00	14.87	14.87	22.60
Hawaii.....	278	214.01	14,590.00	7,387.68	52.48	26.57	45.26
Idaho.....	348	60.38	4,208.90	4,208.90	12.09	12.09	21.86
Illinois.....	17,230	92.09	249,370.87	249,370.87	14.47	14.47	47.57
Indiana.....	2,696	107.26	58,933.44	54,436.15	21.86	20.76	40.23
Iowa.....	18,202	108.20	391,706.76	353,459.39	21.52	19.42	43.44
Kansas.....	1,502	98.72	26,483.89	25,056.66	17.63	16.68	45.19
Kentucky.....	365	94.07	13,072.15	6,631.64	35.81	18.16	26.81
Louisiana.....	628	50.41	6,719.38	6,719.38	10.70	10.70	18.51
Maine ¹	852	89.03	53,723.25	15,436.58	63.06	18.12	26.52
Maryland.....	7,981	77.32	115,202.88	115,202.88	14.43	14.43	34.17
Massachusetts.....	2,706	158.85	75,944.91	75,944.91	28.07	28.07	36.12
Michigan.....	7,759	110.91	261,218.80	165,191.76	33.67	21.37	42.83
Minnesota.....	18,819	65.20	248,206.71	164,468.60	13.19	8.74	37.84
Mississippi.....	8	83.75	220.34	163.34	27.54	20.42	9.75
Montana ¹	208	48.25	7,579.82	2,621.90	36.44	12.61	12.59
Missouri.....	259	127.73	6,359.63	6,359.63	24.55	24.55	40.85
Nebraska.....	4,067	104.26	55,017.18	55,017.18	13.53	13.53	50.96
Nevada.....	116	70.45	1,948.43	1,652.43	16.80	14.24	23.35
New Hampshire.....	2,188	83.90	72,794.29	40,463.99	33.27	18.49	28.08
New Jersey.....	6,135	135.93	182,803.46	148,716.19	29.80	24.24	48.59
New Mexico.....	140	60.66	1,789.54	1,554.36	12.78	11.10	23.40
New York.....	20,976	127.21	1,412,795.92	362,556.16	67.35	17.28	40.55
North Carolina.....	184	83.08	4,015.02	4,015.02	21.82	21.82	13.27
North Dakota.....	1,737	68.50	14,976.14	14,975.94	8.62	8.62	39.45
Ohio.....	13,301	138.18	329,309.16	329,309.16	24.76	24.76	43.42
Oklahoma.....	79	107.75	1,860.71	1,643.83	23.55	20.81	33.89
Oregon.....	682	112.66	7,703.28	7,700.28	11.30	11.30	36.30
Pennsylvania.....	30,653	133.68	1,179,269.63	785,021.90	38.47	25.61	34.92
Rhode Island.....	544	116.67	31,755.00	13,104.84	58.37	24.09	31.72
South Carolina.....	86	77.65	1,649.70	1,649.70	19.18	19.18	20.02
South Dakota.....	1,530	85.76	20,937.05	20,937.05	13.68	13.68	43.05
Tennessee.....	1,731	132.15	5,958.69	4,095.09	34.85	23.95	31.13
Texas.....	793	113.51	17,579.08	17,579.08	22.17	22.17	25.15
Utah.....	814	99.56	15,956.67	15,953.89	19.60	19.60	37.87
Vermont.....	3,651	78.93	53,981.12	53,981.12	14.79	14.79	19.13
Virginia ¹	733	114.87	30,389.41	16,294.03	41.46	22.23	19.06
Washington.....	8,326	133.70	203,135.51	202,847.34	24.40	24.36	43.94
West Virginia.....	379	91.83	8,888.18	5,573.88	23.45	14.71	26.67
Wisconsin.....	29,586	121.96	529,398.48	529,398.48	17.89	17.89	44.44
Wyoming.....	45	129.90	694.49	499.85	15.43	12.22	10.67
Total.....	218,900	111.53	6,189,021.60	4,122,752.54	28.25	18.86	40.01

¹ Salvage paid to State.

ERADICATION OF TUBERCULOSIS FROM SWINE AND FOWLS

Work for the control and eradication of tuberculosis from swine and poultry was continued. A bureau representative was detailed to this work, with headquarters at Des Moines, Iowa, for the greater part of the year. Reports indicate an increasing interest in the problem on the part of State officials, practicing veterinarians, and the livestock industry as a whole. An added incentive in the Corn Belt and the swine-raising States was the action of the packing establishments in notifying producers that hogs from modified accredited areas must be tattooed in order to entitle their owners to the 10 cents per hundredweight premium given for that class of swine. This action became effective July 1, 1928.

The general conduct of the eradication work in poultry continued to include the education of the poultry owner as to the need of proper sanitation, maintenance of flocks under the best conditions of poultry husbandry, and the use of the tuberculin test when necessary for the diagnosis of the disease. The survey of farm flocks in connection with the testing of cattle, inaugurated several years ago, was continued. During the year 226,104 flocks, containing approximately 20,400,000 fowls, in 28 States, were inspected. Nearly 14,000 of these flocks were found to be infected with tuberculosis, as was indicated by physical cases of the disease in the flocks. These inspections were made by veterinarians engaged in the testing of cattle and with very little additional cost to the department.

REGULATION OF INTERSTATE MOVEMENT OF CATTLE

Under the provisions of regulation 7, B. A. I. Order 310, the approved veterinary practitioners throughout 48 States continue to conduct most of the tuberculin testing for interstate purposes. This is logically the work of this group of men. There were on the list of approved veterinarians on June 30 more than 9,200 veterinary practitioners, who, under a cooperative plan, are approved by the State and Federal livestock sanitary officials. These men tested for interstate shipment 35,537 lots containing 404,947 cattle, of which 0.5 per cent reacted. The number tested is an increase of 22,515 cattle over that reported for the fiscal year 1927.

In an effort to assist the livestock owners in facilitating the interstate movement of cattle there were tested under the provisions of the regulations at public stockyards, by bureau inspectors, 50,263 cattle, of which 1.5 per cent reacted. These figures of testing by bureau and approved veterinarians are included in the total testing for the year as reported in Table 25.

Interstate transportation of reactor cattle, also under the provisions of regulation 7, for the purpose of immediate slaughter was continued under the permit system. These permits were issued covering the movement of 40,548 such cattle. The regulations permit the return of breeding cattle to the point of origin when they have been moved interstate and have reacted after delivery. It is noteworthy that no such permits were issued covering the return of such animals. An amendment to regulation 7, effective in the fiscal year 1928, permitted the movement interstate of bull calves under 6 months of age, subject to castration at destination. Permits were issued covering the movement of 17,977 such animals.

TUBERCULIN TESTING

Table 28 indicates the relative use of the various methods of tuberculin testing as reported. The total varies somewhat from the total tests for the year in Table 25 because some of the reports did not state the method of testing.

TABLE 28.—*Relative use of testing methods, fiscal year 1928*

Test employed	Cattle tested	Reactors found	Per cent reactors
Intradermic alone.....	9,381,634	188,622	2.0
Subcutaneous alone....	1,471	32	2.2
Ophthalmic alone.....	461	13	2.8
Combination of tests..	1,351,036	71,480	5.3
Total.....	10,734,602	260,147	2.4

Of the cattle reported as tested in Table 28, about 18.3 per cent were tested by bureau inspectors and about 81.7 per cent by States, municipal, and accredited practicing veterinarians. Considerable pressure was brought to bear on field offices to insure a sufficient amount of field supervision to maintain the tuberculin test at its highest possible efficiency. With more than 900 veterinarians engaged daily

in the work, it can be seen that this was necessary in order that the highest possible standards, established in the past, might be maintained. Attention was again given the so-called no-visible-lesion cases noted on post-mortem examination of slaughtered reacting cattle. Approximately 52.9 per cent of such cases were found to have originated in herds known to harbor infection.

This supervision of field veterinarians was also maintained, so as to reduce the average cost of testing per head. The standard of professional service rendered by the field veterinarians continued to be of a high degree of excellence.

CONFERENCES AND PUBLICITY ON TUBERCULOSIS ERADICATION

The regular Eastern States conference on tuberculosis was held at The Weirs, N. H., June 19, 20, and 21, 1928, and was largely attended by those interested in the eradication of the disease. Other successful conferences were those of the Middle Western States, held at Sioux City, Iowa, April 26 and 27, and the Southwestern States tuberculosis conference, a new conference, held at Oklahoma City, Okla., February 7 and 8. Many valuable contributions to the work were rendered at these gatherings and made available to field veterinarians and others.

A new motion picture depicting the problem of avian tuberculosis was made available. This picture, T. B. or Not T. B., met with very favorable response in areas in which avian tuberculosis is prevalent. The usual distribution of department literature on tuberculosis was continued. A number of exhibits were maintained and distributed for use at county fairs, local meetings, and other assemblies.

DIVISION OF VIRUS-SERUM CONTROL

The activities of this division, consisting of the administrative and regulatory work under the virus-serum-toxin act of 1913, were continued under the direction of D. I. Skidmore, chief. The work consists chiefly in the issuance of licenses to establishments producing veterinary biologic products intended for sale in interstate commerce, the inspection of sanitary conditions and methods of production in the establishments, the supervision of the production and the testing of biologics, and the certification of products for export. It also includes the issuance of permits to

import biologics from abroad, together with the inspection of shipments of biologics at ports of entry.

WORK AT LICENSED ESTABLISHMENTS

Supervision was exercised over 89 licensed establishments in 61 cities and towns in 20 States, as compared with 87 establishments in 60 cities and towns during the preceding fiscal year. At the close of the year 50 establishments were engaged in producing only anti-hog-cholera serum and hog-cholera virus, 33 were producing other biologics only, and 6 were producing both classes of products. Inspectors of the bureau supervised the production and testing of anti-hog-cholera serum and hog-cholera virus, as well as conducting tests to determine whether these products were preserved properly. They also made periodical visits of inspection to establishments producing other biologics. Samples of biologics, as well as cultures of organisms used in their production were collected for examination at the time of many of these visits.

During the year an average of 91 inspectors was maintained in the field. These inspectors examined and admitted to licensed establishments 487,722 hogs and 1,415 calves. Of these, 245 hogs were rejected at the time they were offered for admission and 23,826 hogs were rejected after admission because of conditions which made them unsuitable for the production or testing of biologics. The inspectors also supervised 7,778 potency and 6,159 purity tests of anti-hog-cholera serum.

Inspectors of the division collected 467 samples of biologics or materials intended for use in preparing them. On examination in the laboratories of the bureau, 349 of these samples were found to be satisfactory and 118 unsatisfactory or contaminated. One hundred and forty-one strains of organisms intended for use in the preparation of biologics by establishments were collected and submitted to laboratory examination. Of these, 117 were found to be satisfactory and 24 unsatisfactory or contaminated. The license of one establishment was suspended for 30 days because of violations of the regulations involving the improper preparation of hog-cholera virus and the substitution of well pigs for those sick in tests made of serum for potency and purity. The license of another establishment was suspended for 10 days because of violations involving manipulation of production fig-

ures and false records regarding clear serum, as well as the preparation of a quantity of serum without bureau supervision. The license of a third establishment was revoked because it was found defective, insanitary, and improperly conducted and the products prepared therein contaminated.

OUTPUT OF BIOLOGIC PRODUCTS

During the year licensed establishments produced 1,121,537,853 cubic centimeters of anti-hog-cholera serum, of which 495,234,220 cubic centimeters was defibrinated-blood serum and 626,303,633 cubic centimeters was clarified serum. The quantity of simultaneous hog-cholera virus produced by these establishments was 59,476,317 cubic centimeters, while their production of hyperimmunizing virus amounted to 220,703,133 cubic centimeters and of inoculating virus 876,795 cubic centimeters, so that the total quantity of virus produced by them was 281,056,245 cubic centimeters.

The quantity of other biologics produced by licensed establishments aggregated 29,537,619 doses, classified as follows: Aggressins, 8,976,233; antisera and sera, 1,531,285; avian tuberculin, etc., 533,394; bacterins, 9,530,520; mallein, 97,010; pullorin, 1,032,030; tuberculin, 2,899,880; vaccines and viruses, 4,937,267.

PRODUCTS REJECTED

The quantity of anti-hog-cholera serum destroyed as unfit for use in the treatment of animals aggregated 7,353,967 cubic centimeters. Of this quantity 5,229,853 cubic centimeters were derived from animals affected with diseases such as tuberculosis, pneumonia, and septicemia, and the remaining 2,124,114 cubic centimeters were destroyed because of contamination in the process of manufacture or on account of other conditions which rendered the product unfit for use. The total quantity of simultaneous virus destroyed aggregated 1,556,704 cubic centimeters, of which 799,315 cubic centimeters were destroyed on account of being derived from diseased animals, and 757,389 cubic centimeters because of contamination or other undesirable conditions. The total quantity of hyperimmunizing virus destroyed was 7,583,193 cubic centimeters, of which 6,961,145 cubic centimeters was destroyed on account of disease and 622,048 cubic centimeters on account of contamination or similar conditions.

EXPORTS AND IMPORTS OF BIOLOGIC PRODUCTS

In cooperation with the Treasury and Post Office Departments the bureau exercises control over the importation of veterinary biologics. At the close of the year only one permit to import such products was outstanding. Bureau inspectors examine at the port of entry all shipments of biologics offered for importation, and products not eligible for importation are either denied entry or destroyed. The exportation of biologics from the United States continues to increase. During the year 550 certificates were issued by bureau inspectors to accompany shipments to 24 foreign countries. Although certificates were not required in some cases, the total of all shipments reported to the bureau aggregates 26,669,672 cubic centimeters. Of this quantity anti-hog-cholera serum constituted the major portion, or 23,531,000 cubic centimeters.

ZOOLOGICAL DIVISION

The scientific investigation of animal parasites and the practical application of control measures along the lines of treatment and prevention were continued under the direction of Maurice C. Hall, chief. The division projects were reorganized along the lines of host animals in order to give the arrangement needed for comprehensive consideration of the problems.

An extended survey of parasites in the United States shows a more general distribution of injurious parasites than had been thought to be the case. To make the known control measures more available and more timely, a calendar of livestock parasites has been prepared for general distribution. This supplies seasonal information, especially along the lines of prevention of parasites.

PARASITES OF POULTRY

The investigations on nematode parasites have developed the following facts:

In view of the moot point as to the precise importance of earthworms as carriers of gapeworms and the lack of exact experimental work to determine the rôle played by earthworms, experiments were carried out along this line and are being continued. It was found that when infective eggs or larvæ of gapeworms were fed to earthworms, larvæ identical with the gapeworm larvæ could be recovered from the earthworm tissues, and that when

such infected earthworms were fed to chicks the chicks developed gapes. The present evidence indicates that chicks can be infected directly by swallowing infective eggs or larvæ of gapeworms without the intervention of earthworms, but that gapeworm larvæ swallowed by earthworms leave the digestive tract of the earthworms and enter the body tissues, and that the larvæ in these worms probably live much longer than they would in soil and so serve to carry over infection from season to season.

A special investigation of quail parasites has been carried out in cooperation with the Bureau of Biological Survey. This work has involved the determination of many specimens of quail parasites, the effects of gross infestations on quail, the interrelations of quail and poultry parasites, and the study of life histories of quail parasites.

A new spirurid and a new gapeworm were described from the wild goose and a paper published discussing eight species of pathogenic nematodes either new or previously overlooked in domesticated or game birds in the United States.

The investigations on cestode parasites developed the following facts: Experiments along the line of life histories have established in a preliminary way the life history of *Hymenolepis carioca* as involving intermediate stages in dung beetles, *Aphodius granarius*. The findings reported here are important in view of the work which has been based on results obtained in keeping chickens in fly-proof cages and feeding wild insects such as flies, or the attempts to raise chickens free from tapeworms by using screened inclosures. Such small beetles as species of *Aphodius* are capable of passing through a screen which will keep out flies, a fact which apparently necessitates reconsideration of certain results and proposed measures involving screening.

An experiment still in progress points to a beetle as one host of *Raillietina oesticillus*. In cooperative work with the Bureau of Biological Survey, numerous specimens of tapeworms from quail were identified and found to be, with one exception, the same species that occur in chickens, thus indicating that these species can be spread by both quails and chickens and from each species of bird to the other.

A thorn-headed worm, *Plagiorhynchus formosus*, was found for the first

time parasitic in chickens and another new host, the robin.

PARASITES OF SWINE

Experiments on the life history of the kidney worm, *Stephanurus dentatus*, have so far failed to produce an infestation of the kidneys and perirenal fat when swine were fed infective kidney-worm larvæ. In all these cases feeding experiments have produced an infestation of the liver, with numerous partially developed worms in the portal vein and its branches, usually associated with thrombi. Larvæ were also found in the gastrohepatic artery, apparently the first time they have been found here. Attempts to secure infestation of swine with kidney worms applied to the skin have given negative results thus far, failing to confirm previous reports by other workers.

In these experiments the pathological conditions associated with kidney-worm infestation of the liver have corresponded to the pathological conditions usually reported in meat-inspection procedures as "parasitic livers."

Field work along the lines of adaptation of the swine sanitation system as developed in Illinois has been continued at Moultrie, Ga., to fit the system to southern conditions, especially in the control of kidney worms. The salvage of 24.09 per cent of livers and 16.16 per cent of kidneys and kidney fat, apparently as a result of sanitation, constitutes a large total salvage for a packing plant in the course of a year. One week's investigation of condemnations of parts of swine carcasses for kidney worms and for thorn-headed worms, the latter rendering the intestines unfit for use as casings, developed the fact that the week's loss from such condemnations was \$1,536.22, or an indicated loss of about \$80,000 a year at this one plant. The total loss for the United States must be very large. The scientific data from the swine sanitation work in McLean County, Ill., were published in a technical paper.

Experiments with ascarid ova confirmed the general idea that they do not develop at body temperatures. The eggs underwent normal development at a temperature range of 22° to 25° C. (72° to 77° F.) but prolonged exposure to temperatures of 37.5° (99.6° F.) or more had a lethal effect.

In studies of demodectic mange in swine, eight young pigs free from

symptoms of the disease were turned into a small pen with a young sow which had a well-developed case of demodectic mange. The pigs were examined from time to time and two months later one showed a small lesion on the abdomen and live mites were found in this. About a month later another pig showed a few nodules containing mites. The experiment began October 3, 1927, and by April 1, 1928, the two infected pigs had well-developed lesions, but no new cases had developed.

PARASITES OF RUMINANTS

Among observations of interest in the Washington laboratory was the identification for the first time in the United States of a pinworm, *Skrjabininema ovis*, from sheep, the specimens being sent in from the Nebraska Agricultural College. This worm had been found recently for the first time in Russia in sheep and goats, and has not yet been reported from other countries. A nematode previously described in this laboratory as *Cooperia bisonis* from the American bison was found for the first time in cattle.

The work on control measures for sheep parasites in the South, carried out at McNeill, Miss., has given very valuable and interesting results. As noted in last year's report, the control measures which were successful at Vienna, Va., and in field tests in Missouri, as well as in general farm practice in the Middle West and North, were unsuccessful in controlling parasites at McNeill. During the past year 10 ewes and 11 lambs in one flock were given doses of carbon tetrachloride twice a month, the ewes receiving 5-cubic centimeter doses and the lambs 1 cubic centimeter for each 20 pounds of weight; the drug was given in half-ounce capsules or smaller capsules filled with dry Epsom salt. This measure gave entirely satisfactory control. Following this the same line of treatment was applied to all ewes and lambs, with the same results. It seems clear that on the close, dense pastures of the coastal plains area it will be necessary to shorten the dosing period for sheep under conditions of heavy stocking from every three or four weeks to twice a month. The experiments indicate that when this is done it is possible to secure practically complete control of stomach worms and related parasites and raise sheep profitably. This evidence is confirmed by results obtained at the Mississippi

Agricultural and Mechanical College, where sheep carried on the twice-a-month dosing schedule showed either complete freedom from parasitic worms or only light infestations. At the college the State man in charge alternated the use of copper sulphate with that of the copper sulphate and nicotinic-sulphate solution. Further experiments will be carried out at McNeill to ascertain the relative value of various treatments on the twice-a-month basis to eradicate stomach worms and other worms.

Experiments on cattle parasites at Jeanerette, La., have been carried on to ascertain the value of certain treatments and routine control measures; these experiments will be closed by post-mortem examination later. At the same place a study of anaplasmosis has been begun. Reports during the past year have shown that this disease is widespread in the United States, and that the previous assumption that the disease was confined to the cattle-tick area and transmitted only by the cattle tick, *Boophilus annulatus*, was incorrect. It is now necessary to give this disease special consideration as to its exact nature, mode of transmission, treatment, and control.

The investigations at Jeanerette indicate that worm parasites are probably not a factor of much importance in raising beef cattle at that point.

A continuation of the study of demodectic mange in cattle in the United States indicates that usually not more than 2 to 3 animals in a herd are infested. In some cases an affected animal had been in a herd for 10 years without the disease spreading to companion animals. Experimentally, 6 infested animals were placed with 6 head of cattle of various ages, these animals being kept together for over a year without any evidence of the spread of the disease from the infected to the clean animals. Fifteen attempts to transmit the disease by means of the mite were unsuccessful. It is apparent that under ordinary conditions the disease is not highly communicable and does not spread rapidly.

PARASITES OF HORSES

Studies of horse parasites included a study of *Trichostrongylus axei*, a very small but distinctly pathogenic nematode occurring in the stomach of the horse. American specimens collected from horses in the vicinity of

Washington, D. C., were examined and the pathological changes caused by the worm were given special attention.

To obtain basic information on which to base control measures, studies were made of the fate of worm eggs and larvæ in manure piles, pits, and boxes, of the effects of drying on worm eggs and larvæ, and of the effects of copper-sulphate solution on worm eggs and larvæ. It was found that in manure piles all eggs and larvæ in the central portion are destroyed by the natural heating of the manure within four days. Only the outer portion, from the surface inward to a depth of about 6 inches, contained live parasite eggs and larvæ. In manure in wooden boxes above ground substantially the same was true, the eggs and larvæ in the central zone being killed by heating in the course of four days. Those in the top, bottom, and side portions, to a depth of about 3 inches, remained alive. In manure pits below the level of the ground the results were again similar, the eggs and larvæ being killed in the central zone but remaining alive in the peripheral zone. These experiments are being continued with a view to developing a type of box container in which heating will extend throughout the top, bottom, and side material to destroy eggs and larvæ. The temperatures registered in the central zone were as high as 170° F.

Studies in cooperation with the owner and the veterinarian of a horse-breeding farm at Lexington, Ky., on the effects of drying showed that the eggs and preinfective larvæ of horse strongyles were killed by exposure to air on glass slides for several hours. The infective larvæ have a relatively high resistance to drying.

A preliminary test of the killing power of copper-sulphate solution showed that preinfective or infective larvæ were destroyed by several hours' exposure to a 1 per cent solution. It was also found that although these larvæ were alive and active after one hour in the solution, the larvæ died even after being washed several times to remove traces of the chemical and then left in water, while check larvæ remained alive and active in water. The division also cooperated with the Veterinary Corps of the United States Army in measures to control parasites, especially at the remount stations and in brood mares and foals.

MISCELLANEOUS PARASITES

It has become evident that parasites are making headway in the United States faster than attempts at control are overtaking them. This condition follows from the rapid change from range to farm conditions with denser stocking of more valuable animals on smaller areas of more valuable land and from the far and wide distribution of parasites by means of modern rapid transportation of livestock. In the search for control measures having wide applicability, in lieu of the development of special control measures for each parasite species, it has been thought that a pasture spray might be developed which would serve to control all or many of the numerous strongyles which infest livestock.

As a preliminary attempt at control by spraying, experiments have been carried out with copper sulphate. A 1 per cent solution proved to be lethal for the species of horse strongyles used. To test the possible danger to animals from the spraying of pastures, an experiment was carried out in co-operation with the experiment station at Bethesda, Md. The experimental animals, consisting of a horse, cow, and sheep kept on pasture, so sprayed were in good condition and showed no bad effects from the use of grass sprayed with copper sulphate four times in the course of a month. The experiment was renewed in June, 1928, and is being continued. A similar experiment with a pasture used by sheep is being carried out at McNeill, Miss., and another with a horse pasture at Lexington, Ky.

Two important observations on tapeworm parasites of man were as follows: Specimens of tapeworms sent in from Porto Rico from a man and from the chimpanzee were found to be identical species, *Bertiella mucronata*, a form previously reported only twice in the literature and in both previous cases only from primates other than man. The new record is the first case of the occurrence of this tapeworm in man.

On post-mortem examination of a giraffe that died at the National Zoological Park, Washington, D. C., an unarmed cysticercus was found in the liver. Three of these cysticerci were swallowed by a member of the division staff to determine whether they belonged to a form capable in its adult state of infesting man. After two months and 17 days, gravid segments

were found in the feces. Anthelmintic treatment some time later expelled numerous fragments of tapeworms, but no heads were found. The precise identity of the tapeworm has not yet been settled, but it appears unlikely at this time that this worm is *Taenia saginata*, the common unarmed tapeworm of man.

Feeding experiments with the salmon-poisoning fluke, *Nanophyetus salmincola*, furnished by the Oregon Experiment Station, produced typical symptoms of salmon poisoning and apparently the presence and effect of the parasite resulted also in the severe aggravation of symptoms of demodectic mange in the cases of dogs showing slight lesions prior to feeding. It was also found that the eggs of this fluke required three months to hatch, an unusually long period for fluke eggs. Numerous additions were made to the collections of specimens and illustrations.

TREATMENTS FOR INTERNAL AND EXTERNAL PARASITISMS

Laboratory tests of treatments for infestations of the intestines of chickens with a hairworm, *Capillaria columbae*, have shown that carbon tetrachloride is usually quite effective in destroying many or most of the worms present. This treatment was tested by a poultryman on a thousand birds with good results. Tetrachloroethylene was also promising in laboratory tests, but chenopodium did not appear to be effective.

Tests of various kamala extracts on dogs indicated that these were effective in removing *Taenia*, but not very satisfactory in removing *Dipylidium*, kamala powder being apparently more effective against *Dipylidium*.

Tests of drugs for the removal of thorn-headed worms from swine were

not conclusive but were promising, a matter of interest since the drugs previously used have been rather ineffective.

Carbon tetrachloride, developed as an anthelmintic in the Zoological Division, is reported as having been given in 15,000,000 treatments for hookworm disease of man.

Tests of various repellent substances used in wading tanks as a possible control measure for ox warbles indicate that when such things are used the adult warble flies deposit their eggs above the treated surface, and that this control measure is inadequate.

Experiments with several cows affected with demodectic mange indicated that sunlight, sanitation, and good feeding may prove of value in the control of this condition. The results were better than those obtained by the use of coal-tar-cresote dips repeated several times at 5-day intervals.

INDEX CATALOGUE AND COLLECTIONS

The index catalogue of medical and veterinary zoology was continued and, as usual, a number of investigators visited the laboratory to take advantage of it. In collaboration with the Zoological Division of the Hygienic Laboratory, United States Public Health Service, the final number of the host catalogue dealing with parasites of man was published. The previous sections dealt with the Protozoa (1925), worms (1926), and Crustacea and Arachnoidea (1927); the latest section deals with the insects of medical and veterinary significance. Subsequent sections will deal with hosts other than man.

The specimen collection was increased by 120 bottles of material and the collection of illustrations was increased and filed systematically.

DEC 14 1928
EXPERIMENT STATION FILE

REPORT OF CHIEF OF BUREAU OF BIOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., September 1, 1928.

SIR: I have the honor to transmit herewith a report on the work of the Bureau of Biological Survey for the fiscal year ended June 30, 1928.

Respectfully,

PAUL G. REDINGTON,
Chief.

Hon. W. M. JARDINE,
Secretary of Agriculture.

WILD LIFE RESEARCH AND ADMINISTRATION

Research, service, and regulatory functions with regard to wild life embrace all the varied operations of the Bureau of Biological Survey. In these three branches the bureau has enjoyed continued cordial relations with scientific institutions and individual research workers; with officers of State departments of agriculture, extension services, livestock and other associations, cooperating stockmen, and farmers; and with State conservation departments, the Alaska Game Commission, sportsmen's associations, hunting clubs, and individual sportsmen and other conservationists. Through the interest of cooperators in the varied duties assigned to the Bureau of Biological Survey, the influence and helpfulness of the bureau is greatly extended, far beyond the sphere of activity of the limited force of workers that can be carried on its rolls.

Fundamental to all other functions of the bureau is the important branch of research. The scientific investigations of the survey cover studies of the distribution and habits of wild-life forms, their economic status as determined by food and feeding habits, the conservation and propagation in captivity of useful wild mammals and birds, and methods of reducing the damage wrought by predatory animals

on livestock and on game and other useful species, by rodents on farm and forage crops, and by other forms that are otherwise economically injurious. The importance of extending the research work of the bureau can not be too strongly stressed. Without it, the service expected by the public and by the various States in advice and co-ordination of effort in wild-life conservation, utilization, and control can not be properly rendered.

Dependent upon the research work of the bureau and developing from it is the branch of service, the activities of which consist for the most part in disseminating the information gathered; work for the benefit of the public, not primarily involving research, described as wild-life control, either in independent operations on public domain or in organized campaigns conducted cooperatively with State, Territorial, or other agencies; and wild-life conservation through the administration of bird refuges and big-game preserves.

The future enjoyment of wild-life resources is dependent upon the administration of conservation laws and related regulatory and educational activities. The laws administered by the Bureau of Biological Survey, through the preparation and enforcement of regulations, include (1) the migratory bird treaty act, (2) the Lacey Act, regulating interstate com-

merce in wild-life forms and their importation from foreign countries, (3) the act protecting wild life and property on game and bird reservations, (4) the upper Mississippi River wild-life and fish refuge act, (5) the Bear River migratory bird refuge act, (6) a section of the tariff act of 1922 (sec. 1569) authorizing regulations to control the importation of eggs of game birds, and (7) the Alaska game law, through representation on and cooperation with the Alaska Game Commission.

ORGANIZATION CHANGES

Just before the close of the year a reorganization of the activities of the bureau on conservational lines was effected in the consolidation of the division administering game and bird reservations and Alaskan wild life with the division of migratory-bird treaty and Lacey Acts administration. The new division of game and bird conservation is under the leadership of H. P. Sheldon, formerly in charge of the latter division. His title has been changed from chief United States game warden to United States game conservation officer. The change in administrative direction permits the assignment of E. A. Goldman, formerly in charge of the reservations division, to research work, to continue scientific investigations that had been interrupted by administrative responsibilities. The wardens of the two former divisions will now be known, respectively, as United States reservation protectors and United States game protectors, but cooperating State and other officials detailed to enforcement of the migratory-bird treaty and Lacey Acts will still be designated United States deputy game wardens. The change in organization was made with a view to preventing what was seen to be a tendency toward overlapping of functions of the two divisions, and will be in the interest of better correlation of the work of the bureau and of greater efficiency and economy, particularly in the further development of the migratory-bird refuge program.

A further change in leadership within the bureau was brought about on February 16, 1928, when A. K. Fisher, connected with the Bureau of Biological Survey ever since its organization in 1885 and since 1909 in charge of the division of economic investigations, was assigned to scientific work to round out material on the economic status of hawks and owls, a subject on which he has long been a recognized authority. He was succeeded

by Stanley P. Young, by transfer from active predatory-animal field operations in Colorado, and for the past year assistant in the direction of the division. W. E. Crouch, for 12 years a leader in rodent-control operations in Idaho, was brought to Washington to assist Mr. Young.

CHIEF ACCOMPLISHMENTS OF THE YEAR

Among the landmarks placed during the year that indicate definite accomplishment in wild-life administration or forward-looking legislation to promote conservational programs, may be mentioned the following, the details concerning which are set forth in this report, together with the urgent need for still greater constructive advance:

Inauguration of studies of changing abundance of migratory wild fowl from year to year, through systematic and repeated censuses taken by co-operators of the Bureau of Biological Survey on important concentration areas.

Authorization by congressional legislation of more extended research having to do with the relations of wild life to forestry—the effects of birds, mammals, and other forms on forest production.

Successful crossbreeding of Alaskan reindeer with native caribou captured for the experiments, and the birth of fawns of materially increased weight.

Progress in research work on the food of the English sparrow through the completion of examination of thousands of stomachs collected throughout the country, the first stage necessary to the preparation of a final report.

Establishment of the rabbit experiment station in California to supplement other investigations on the production of rabbits for fur and food.

Definite progress through cooperative effort in investigations of diseases of foxes and measures for their prevention and cure on fox farms.

Development, through a conference of field leaders in rodent and predatory-animal control at Ogden, Utah, of improved plans for research work and definite policies in local and general control operations. Congress requested that there be submitted to it at the next session a plan that will operate to insure adequate control of the predatory animals throughout the country.

Authorization by Congress of a refuge for migratory birds in the extensive Bear River marshes, Utah, and first steps in its administration, as an aid to conserving the wild-fowl resources of the West.

Greater expedition in the work of acquiring lands for the upper Mississippi wild-life refuge through congressional aid and through private donation of areas important to the purposes of the refuge.

Definite progress in studies of the requirements of the Wyoming elk, in the administration of other game animals and birds on reservations, and in coordination of State and Federal policies in wild-life administration generally.

The development of additional refuge areas for wild life has been brought more intimately to public attention, and the sentiment throughout the country is more definitely crystallized in favor of a unified program, as it becomes generally understood that the onward march of civilization, with its farming and industrial operations, threatens at least locally the ultimate extinction of the various forms of wild life that were the delight of our forebears and that can not be perpetuated for future enjoyment unless provided with free range, including feeding, breeding, and resting grounds.

BIOLOGICAL INVESTIGATIONS AND LIFE-HISTORY STUDIES

Research is an absolute essential to progress in wild-life administration. The Federal Government alone can not be depended upon to solve all the problems involved. Cooperation of all agencies—States, Federal bureaus, associations, and individuals—to provide reliable and specific facts for long-time programs of conservation is a very definite obligation. All problems affecting wild-animal life should be considered not alone from the standpoint of the present but of future generations. Constructive programs must be put into effect that will make available to all the people the wholesome influences of the great outdoors, including the stimulus of wild-life association. During the past year particularly important progress has been made in projecting clearly defined plans of research to these ends, and in enlisting the cooperation of organizations interested in these undertakings.

INVESTIGATIONS OF WILD FOWL AND BIG GAME

WATERFOWL CENSUSES

The response made by observers throughout the country to the appeal of the bureau for assistance in gath-

ering more complete information regarding the abundance, distribution, and movements of waterfowl has been most gratifying. More than 3,000 observation stations have been established, representing every State in the Union and all the Provinces of Canada, as well as Alaska and Porto Rico. Reports from these stations are made by volunteer observers on selected dates once each month, each giving results of actual field observation on a waterfowl-resort area typical of the region. Cooperation has been obtained from virtually all State game and conservation commissions, chiefly through their warden forces; from Canadian authorities, through cooperation of the Office of National Parks of Canada and game officials of the Provinces; from sportsmen's and conservation organizations; and from individuals. Federal bureaus include the Forest Service, the Weather Bureau, and the Extension Service of the Department of Agriculture, the National Park Service, the Office of Indian Affairs, the Bureau of Reclamation, and the Bureau of Education of the Department of the Interior; the Bureau of Lighthouses and the Bureau of Fisheries of the Department of Commerce; the Coast Guard of the Treasury Department; and the Office of Engineers of the War Department. The work has been aided also by such State and national organizations of sportsmen and conservationists as the American Wild Fowlers, the American Game Protective Association, and the Izaak Walton League of America.

The work of cooperators has been stimulated, systematized, and checked up through field contacts by the leaders, and the reports received, totaling many thousands, furnish the basis for a far more detailed and comprehensive knowledge of the status of waterfowl in North America than has heretofore been available. The information has been carded and indexed for ready reference, and preliminary maps prepared showing in a graphic way conditions that must be given consideration in formulating plans to insure the maintenance of waterfowl in satisfactory numbers. The results of this survey will become increasingly valuable as they accumulate over a period of years. The undertaking has crystallized and put into effect the feeling of leaders in game-conservation work throughout the country that practical broad-gauge efforts must be made to obtain the facts as a basis for effective administration.

STATUS OF THE WOODCOCK

Inquiry was made and reports were received from more than 300 selected observers among ornithologists and sportsmen regarding the status of the woodcock throughout its present range. The information thus obtained was tabulated and compared with that already on hand in considering the many proposals received regarding measures essential to the adequate protection of this interesting and valuable game bird and in amending regulations governing the open season.

The migratory-bird treaty-act advisory board has recommended that the Bureau of Biological Survey carry out a detailed investigation of the woodcock throughout its range. Much essential information concerning this bird is lacking. A closer check on the migratory flight lines by extensive field study and banding operations is desirable.

ELK IN WYOMING

In accordance with plans developed in the preceding year, in cooperation with the State game and fish commission of Wyoming, the Forest Service, and the Bureau of Animal Industry, an experienced biologist has been engaged throughout the year in a study of the Jackson Hole elk. This is in harmony with recommendations made by the commission appointed by the President's committee on outdoor recreation. Detailed and comprehensive information is being obtained regarding the number, the breeding and feeding habits, and the seasonal movements of these elk, as well as their range and food requirements in relation to livestock grazing, and their diseases and parasites or other causes of depletion. The Bureau of Plant Industry and the United States National Museum have aided by identifying important forage plants consumed by the elk. Study of the grazing habits of the elk is being made in accordance with methods used by the Forest Service in studying the grazing habits of livestock, in order that the results may be useful in working out plans helpful to the local game and livestock interests, as well as to those of other regions where similar studies are needed. The seasonal movements of the elk and such influencing factors as food, temperature, shelter, and insects are being studied. Observation is being made on the influence of predatory animals, including cougars, wolves, and coyotes, on the decrease of the

elk. Statistics are not now available on the number of elk killed by hunters, but the State fish and game commission of Wyoming has arranged to obtain reports on this subject in connection with the issuance of future licenses. No cases of starvation were observed during the past winter, during which conditions were rather favorable, and it is believed that there were few, if any. All animals examined had full stomachs, and in few cases was the food improperly digested.

Elk parasites collected, and later identified by the Bureau of Animal Industry, included tapeworms and cysts, lung worms, grubs, and ticks. One adult bull elk and two adult cows were found affected by scab, and several others were reported. Particular attention was given to diseases throughout the winter and spring. A total of 409 animals were found dead, and 193 postmortem examinations were made. Of this number 70 showed definite evidence of necrotic stomatitis, and others presented indications of this disease. The diagnoses are based largely on the reports made by the Bureau of Animal Industry on diseased tissue submitted. These studies involved about 7,000 animals, so the total loss was approximately 5.8 per cent. There was a total of about 1,406 calves with a known loss of 259, or approximately 18 per cent. The presence of squirrel-tail in the hay and undue concentration of the herds on feeding grounds are apparently largely responsible for the prevalence of necrotic stomatitis. If these causes can be eliminated or reduced the herd will be safer from ravages of epizootic diseases. It seems impracticable to treat diseased elk, hence preventive measures are required.

The ideal arrangement would be to maintain the elk in as nearly a wild state as possible. Effort should be made in the direction of preserving the elks' natural instincts, so that they will care for themselves properly and obtain their own food as far as possible. The feeding of hay in severe winters will doubtless continue to be necessary, but the feed should be free from disease-inducing plants.

ELK IN ARIZONA

At the request of the Forest Service and of State officials in Arizona, a representative was detailed to the Chiricahua Mountains to investigate and report on the practicability of introducing elk into that region. His study was made in cooperation with

representatives of the Forest Service, the State game department, the State game protective association, and the local stockmen's association. Consideration of all the factors involved appeared adverse to the proposal, but it was recommended that effort be made to increase such other desirable game species as mule deer and wild turkey.

DEER IN PENNSYLVANIA

In response to an urgent call from the board of game commissioners of Pennsylvania a biologist was detailed to examine conditions attending the large loss of deer in certain parts of that State. His studies revealed conclusive evidence of overstocking, overgrazing, and consequent starvation of thousands of young deer. Copies of the report were furnished to the State board of game commissioners, the Forest Service, and the game departments of other States where similar conditions might obtain, and it was also republished extensively in periodicals devoted to game interests. The report included information regarding the history of game management in Pennsylvania, the present abundance of deer, their food habits and food supplies, damage by deer, and the losses that had occurred, with suggestions for improving game-management practices. Many letters received indicate that similar losses occur in other sections, and this analysis of conditions in Pennsylvania is thus proving helpful in other States.

BROWN BEARS IN ALASKA

Some concern has been felt relative to the status of the Alaskan brown bear, but investigations conducted by the survey in the spring of 1928 indicate that there has not been such a serious decrease in the numbers of this unique American animal as to warrant fear of its extermination.

STUDIES OF OTHER BIG GAME

A number of other special studies were carried on during the year, including investigations in cooperation with the Office of National Parks of Canada and the American Wild Fowls concerning destructive agencies and other factors that affect the numbers of waterfowl on their breeding grounds.

A report on the caribou of Alaska, based on studies carried on during the past several years, was prepared for publication.

COOPERATIVE STUDIES OF WILD LIFE IN FORESTS AND PARKS

MAMMALS AND BIRDS IN SOUTHERN FORESTS

In cooperation with the Forest Service a preliminary study was made during the months of April and May at the forest experiment station on the Bent Creek area of the Pisgah National Forest in North Carolina to determine the numbers, activities, and habits in relation to forest production of the mammals and birds inhabiting the area. Four areas of 2 acres each in three distinct forest types were selected for trapping operations. These were visited daily to remove specimens and record observations.

Studies also were made of injury by rodents or other animals to seedlings and young growth of valuable forest trees. Lists of birds and mammals found on the experimental areas and in the vicinity were kept, and observations made regarding their numbers and general feeding habits that might be a factor in the success of forest production. The stomachs of all rodents collected were preserved for laboratory study.

PORCUPINES IN RELATION TO FOREST PRODUCTION

Studies of the porcupine have demonstrated that this animal is seriously important economically, and that where it is locally abundant control operations may be needed. In the Southwest porcupines occur commonly in places on the Tusayan, Coconino, Carson, and San Juan National Forests. Although characteristically forest animals, they may be found at considerable distances from trees, and are partial to ridges, gullies, rocky breaks, caves, and boulder slopes. In this region they prefer the bark of moderate-sized yellow pines to that of other trees, but injure also other pines, firs, spruces, and junipers.

In certain parts of the Southwest porcupine damage is probably second only to that caused by fire and mistletoe. In larger trees the damage is chiefly to the tops, the upper portions of the trunk being so peeled and girdled that the summit of the tree is either killed or deformed. Porcupines also consume a considerable quantity of foliage, thus retarding the growth of trees. The fact that porcupines often revisit particular trees in the course of their wanderings through the woods has afforded a vulnerable

point of attack in planning control work.

CONTEMPLATED STUDIES OF FOREST ANIMALS

Forest wild-life research will be conducted on an increasing scale in accordance with provisions of the recently enacted McNary-McSweeney bill, which provides for the gradual, effective development of a forest-research program. Among other lines of research it authorizes participation by the Biological Survey in experiments and investigations in determining the life histories and habits of forest mammals, birds, and other forms of wild life, whether injurious to forest growth or of value as a supplemental resource, and in developing the best and most effective methods for their management and control. This is a most far-sighted and important piece of legislation and will make possible the systematic organization of research and the assembling of basic information essential for national, State, and local programs for the development of forests and forest resources.

ANIMAL LIFE IN GRAND CANYON NATIONAL PARK

Near the close of the fiscal year conferences were held and plans arranged for cooperation with the Carnegie Institution of Washington, the National Academy of Sciences, the National Research Council, and the National Park Service in efforts to learn what correlations there are of the present animal and plant life with that of the geological formations in various national parks. This investigational and educational program, beginning in the Grand Canyon of Arizona, should afford important and interesting information regarding features to be observed by visitors to the parks.

INVESTIGATIONS IN GEOGRAPHIC DISTRIBUTION

BIRD MIGRATION

Many records have been added to the geographic distribution files of the Bureau of Biological Survey during the year from data gathered by correspondents and cooperators, and from general literature, about 40,000 additions having been made to this valuable file of approximately 1,500,000 records. Maps of the breeding ranges of many species have been revised. Progress has been made in the preparation of a bulletin on the distribution and

migration of North American swallows. Revision of a circular on the spread of the European starling in North America to 1928 was completed and forwarded for publication at the end of the year, supplementing the information published in 1925. Technical Bulletin No. 26, *Our Migrant Shorebirds in Southern South America*, which sets forth the dangers that beset many of the northern species in their winter homes, was issued during the year. Another outstanding report, Technical Bulletin No. 61, *Wild Birds Introduced or Transplanted in North America*, prepared by John C. Phillips, a collaborator of the bureau, details the meager success that has attended the numerous efforts to introduce foreign birds and transplant native species. Bird-migration records have been brought to date and include reports received during the year from the 200 cooperative observers.

BIRD BANDING

The banding of birds continues to yield increasingly interesting and valuable information. The opportunities afforded by this method for intimate acquaintance with the birds and for obtaining definite information regarding their habits, migratory movements, and distribution, make a strong appeal to bird students. The number of qualified cooperators has continued to grow steadily until a point has been reached where existing facilities for this investigation are inadequate to meet the demands upon the bureau. A great accumulation of data emphasizes the necessity for the publication of reports that are demanded by educational institutions, cooperators, and bird students generally. At the close of the year more than 1,400 persons, including 99 in Canada, were on the list of bird-banding co-operators. The methods employed and the results obtained have aroused much interest in European countries, and a comprehensive account of trapping methods for "ringing" birds, as banding is termed in England, was prepared in the Biological Survey and published in November in *British Birds Magazine*.

During the year 195,000 bands were purchased for the use of cooperators, and the number of birds already reported as banded during the year totals 127,105, an increase of more than 35,000 over the previous year, bringing the total banded since 1920 to more than 400,000. Return records reported during the year total approximately

7,000. Technical Bulletin No. 32, Returns from Banded Birds, 1923 to 1926, including tabulations of the more than 10,000 sets of return data received, was published during the year, and a popular explanation of the purposes and accomplishments in bird banding appeared in the 1927 Yearbook. An extended popular article, Bird Banding, the Telltale of Migratory Flight, published in the National Geographic Magazine in January, elicited much favorable comment.

Outstanding during the year was the banding of 5,000 mallard ducks at the National Bison Range, Moiese, Mont., returns from which show that birds from that section winter chiefly on the Pacific coast, from Washington south to southern California. This is one of the many instances where significant information has been obtained regarding the movements of waterfowl. The percentage of returns to the total number of waterfowl banded should afford a basis for calculating the approximate numbers of these birds when reliable information is obtained regarding the annual kill by hunters. A manuscript on this phase of the work has been prepared for publication under the title "A Method of Determining the Annual Fluctuation in the Abundance of Waterfowl."

Progress has been made in the preparation of a manual showing the most satisfactory methods of trapping and handling birds for banding. Bird banding is stimulating its devotees to record the results of their work, and is thus yielding information of importance, as indicated by a list of more than 500 articles on the subject, recently compiled in the bureau.

CENSUSES OF NONGAME BIRDS

The censuses of birds other than waterfowl have been continued as in previous years and provide valuable data regarding the breeding of birds on selected areas throughout the country. The reports of cooperative observers provide specific information regarding the relative abundance of species, and the observations accumulating over several years yield data for a better understanding of the abundance and breeding habits of this class of birds.

BIOLOGICAL SURVEYS OF MAJOR AREAS

Further progress has been made during the year toward the completion of a biological survey of Wisconsin. A report on the mammals and life zones of Oregon was practically com-

pleted, one on the birds of Washington was finished, and one on the birds of Florida is well under way. An extensive report on the birds of New Mexico was in press at the close of the year, being published by the State game commission of New Mexico in cooperation with the State game-protective association and the Biological Survey. Comprehensive reports finished during previous years, but still awaiting publication, include annotated lists of the birds of Texas and of the mammals of New Mexico.

IDENTIFICATION AND TAXONOMIC WORK

Conclusions in research on any of the biological sciences have little, if any, scientific worth unless the identification of the species involved is accurate. The work of identifying specimens is particularly vital in studies along economic or medical lines, since wrong determinations may result in losses of property or even of human life. The direct bearing of taxonomic work on all phases of the operations of the bureau and of cooperating Federal and State agencies and education institutions makes desirable a considerable enlargement of this phase of the survey's work. The scientific collections of the bureau now include approximately 63,000 birds and 135,000 mammals. Not only are these collections the basis of important research work of the staff, but they are also available for the use of special workers in other institutions. During the year a revision of the North American lemming mice was published in the series of the North American Fauna (No. 50), and at the end of the year a review of the American long-tailed shrews (North American Fauna No. 51) was in press.

LIFE HABITS OF INJURIOUS AND BENEFICIAL SPECIES

Mammals, especially certain rodents, may often become serious pests, and, on the other hand, many mammals are mainly beneficial in their effect on the soil and in their control of various fungi, rusts, or insects that might otherwise do extensive damage. Recent studies of the life habits of mammals have been concerned chiefly with jack rabbits, ground squirrels, prairie dogs, kangaroo rats, and porcupines.

RODENTS AND RANGE FORAGE IN ARIZONA

Biological investigations in the Southwest have dealt primarily with

the relations between native rodents and range forage, conducted in co-operation with the Forest Service, the University of Arizona, and the Carnegie Institution of Washington. Quantitative determinations of the food of rodents have served to emphasize the importance of these relations. The work has demonstrated that the native animal population of the Southwest is a fundamental factor in range management.

Intensive studies have been conducted to determine the effect of native rodents on plant growth, particularly forage. These included the results of overgrazing by native rodents, a habit that prevents satisfactory reproduction of some of the more valuable plants, thus causing them to be crowded out by others less desirable. Several experimental plots are maintained in Arizona, and on these the experiments have proved that palatability of plants obtains with rodents as well as with livestock, and that prairie dogs and cattle have essentially the same order of preference for the more palatable and nutritious grasses. Analyses of data obtained on the experimental plots over a 10-year period have shown that prairie dogs often reduce production of the more valuable forage grasses from 25 to 80 per cent. In some instances they have been known to destroy some of the more valuable grasses over extensive areas.

There is an intimate relation between the number of rodents and the available forage, the rodents tending to multiply in direct proportion to the increase in food. It is thus clear that if stockmen wish to reap the benefits from the increased forage that comes with improved range management they must control the rodents.

JACK-RABBIT DEPREDACTIONS

Investigation of the life history and habits of jack rabbits has shown that these are among the most important of the rodent pests over considerable areas in the Southwest and West. Stomach contents examined show that their principal food there is mesquite, chiefly leaves, although pods are frequently eaten. The grass destroyed, which is next in importance, can not be shown by calculations based entirely upon the quantity of food eaten, as much is cut down and left lying on the ground.

Feeding experiments with the black-tailed jack rabbit in Arizona showed that on the average 18 rabbits eat 1

ton of dry forage in the course of a year. Weights of the antelope jack rabbit average about 9 pounds; of the adult black-tailed jack rabbit about 5½ pounds. These animals have been found highly adaptable as to food and feeding conditions. At dry periods they consume much cactus, but as soon as other vegetation appears they leave this for more palatable plants. They consume the same foods that livestock eat, but are likely to be more destructive to both grasses and browse since they graze more closely.

Investigations of the breeding habits of both the antelope and the black-tailed jack rabbits have shown that the breeding period extends over at least nine months, from December to September, during which time several litters may be produced. In extremely arid sections rabbits are likely to be very scarce, while on slopes at the bases of the mountains where the grasses are best they are more abundant.

ANIMAL PESTS OF BULBS

In the Pacific Coast States studies of the habits of rodents, moles, and certain birds in relation to the growing of bulbs and bulbous plants were continued. These were designed to provide information to meet the needs of American bulb growers in a region where an important new industry is in the making, the soil and climate being favorable for bulb production to supply the winter trade of florists. Certain types of plantings have been found particularly susceptible to rodent injury, and some to attack by introduced game birds.

Throughout Oregon and California the pocket gopher is the chief offender, by reason of its general distribution and its persistent habit of storing food. In the more northern coast sections, meadow mice primarily, and moles as accessories, constitute serious pests. Experiments were conducted to determine means to protect bulb plantings by controlling the animals.

BEAVER TRANSPLANTING

Studies were continued of the habits of beavers, and work was done in improving methods of taking these animals alive in localities where they are troublesome. Experiments were continued also in establishing them in situations where they are desired to conserve water and promote fish production, to provide a source of profit from their pelts, or to furnish objects of

interest and attraction, as in parks. Technical Bulletin No. 21, Beaver Habits and Experiments in Beaver Culture, bringing to date the details of this project, was issued during the year.

HARBOR SEALS IN COASTAL WATERS

Some work on the feeding and other habits of the harbor seal served to call attention to the urgent need of establishing definitely the economic status of this species and of the larger sea lion, through study of their relations to the fishing industry. The Bureau of Fisheries of the Department of Commerce expressed a desire that the survey obtain information on the subject as a basis for determining policies of State and Federal Governments with reference to these animals in waters along the Pacific coast, including Alaska.

TULAREMIA AND ITS SPREAD BY WILD ANIMALS

In response to requests made at the national game conference of the American Game Protective Association, at which tularemia in wild animals was discussed by bureau representatives, a mimeographed circular was issued to summarize pertinent information regarding this epizootic disease as it relates to game animals and birds, with information as to practical ways by which hunters or others handling carcasses of infected animals might safeguard themselves. Quarantine measures were recommended to prevent the introduction of diseased animals for restocking. Copies of the circular were sent to game commissions, sportsmen's and conservation periodicals, and the public press, and served to bring to the attention of the public generally the importance of exercising care particularly in handling wild rabbits to avoid infection with this debilitating or even fatal disease. The active interest of sportsmen, conservationists, and game officials was enlisted in preventing introduction of the disease among the native stock through the liberation of the game animals affected. One shipment of wild rabbits, sick and dying from tularemia, was detected and promptly destroyed by game officials in Massachusetts, one of the few States in which the disease has not been found among native animals or human beings.

Progress has been made in investigations inaugurated by the Bureau of

Biological Survey in cooperation with the United States Public Health Service to determine the possible susceptibility of ruffed grouse and other game birds to tularemia. The blue grouse was found susceptible to the disease following laboratory inoculation with virulent material from diseased animals at the spotted-fever laboratory of the Public Health Service at Hamilton, Mont., and similar results were obtained with the ruffed grouse in cooperative investigations at the University of Minnesota. Studies are being continued to determine whether these and other important game birds may be infected by rabbit ticks or other natural carriers, and whether the disease may be prevalent among them in a wild state.

ALASKA REINDEER INVESTIGATIONS

The chief problems in reindeer investigations are concerned with breeding and feeding; the reaction of the reindeer and caribou to handling; reproduction, carrying capacity, and the worth of Alaska forage plants in grazing use; and the development of a satisfactory plan for range management. Investigations are conducted at the bureau's reindeer experiment station at Fairbanks, Alaska, and on typical grazing areas elsewhere in the Territory. Assistance also is given to reindeer owners at their round-ups in demonstrating improved methods of counting, marking, and ownership distribution of animals.

A member of the station staff was detailed to Washington during the winter and visited various points in the United States where grazing investigations were in progress, in order to note improved methods and equipment adapted to Alaskan conditions.

Through the courtesy of an Alaska reindeer corporation, several reindeer carcasses were furnished for use in studies in the department laboratories in Washington to determine the most satisfactory market cuts, the chemical and nutritive properties of the meat, and improved methods of dressing, handling, storing, and cooking. These investigations were conducted in cooperation with the Bureaus of Agricultural Economics, Animal Industry, and Home Economics of this department, and in consultation with the Alaska division of the Bureau of Education of the Department of the Interior, which supervises reindeer production and use among the natives of Alaska.

REINDEER EXPERIMENT STATION

Early in the winter the Alaska Railroad Co. constructed a substantial house on the railroad right of way on the campus of the Alaska Agricultural College at Fairbanks and furnished it as residence quarters for the reindeer experiment station staff. Transfer to these quarters was made on January 1. Through the cooperation of the Alaska Agricultural College, office space also was provided in the main building of the college. This provision of quarters and office space for the experiment-station staff has greatly facilitated progress in investigational work.

Fencing was completed on two pasture areas of 32 and 325 acres, respectively, at the station, and three transfer corrals and one shelter shed were erected. In addition fences have been started on four additional pastures of 390, 58, 72, and 20 acres. This equipment at the station has been provided with a view to handling about 75 reindeer and caribou for experimental investigations and for inclosing a small herd of buffalo from the national bison range, Montana, to be kept under observation there. The total station area under fence at the present is 397 acres; that in process of completion is 520 acres; leaving about 260 acres to be fenced the coming year. Additional lands have also been made available by Executive order for use in the station work.

REINDEER FORAGE STUDIES

Quadrat studies of forage were continued during the year, and additional inclosures were established both in the interior and on the Bering Sea coast. These are designed to provide definite information regarding vegetative succession and climaxes, as well as plant reproduction and reaction under grazing use, and should afford a basis for conclusions regarding carrying capacity and range management.

Three initial carrying-capacity projects on lichen range were completed during the winter. These, supplemented by lichen-feeding tests in the feed lot, indicate a winter requirement per animal of 20 to 30 acres, based on the average range, and that probably a 30-year recovery period will be necessary. Further study on an extended scale is necessary for a more definite determination of both forage value and recovery period.

Under the most favorable conditions in feed lot or in pasture during light

snow cover, where the food was easily accessible the reindeer and caribou held their own on the lichen diet or made minor gains. Under severe conditions, however, with the snow cover about 2 feet in depth, where the animals were forced to rustle extensively for their food they lost in weight, the average loss per animal over an 84-day period being 17 pounds. These tests have demonstrated clearly that the lichen forage is not a fattening food but merely a convenient maintenance forage for winter use. The lichen requirement per head per day is 20 to 30 pounds, air-dry weight, for animals averaging about 175 pounds.

FEEDING EXPERIMENTS

Feeding studies have been continued to determine the cultivated foodstuffs that reindeer and caribou will eat and the quantities required. This is in preparation for further study as to the economic possibilities of winter feeding in connection with local farming operations and as to the effect of such feeding on meat production. It has been demonstrated that reindeer will thrive on cultivated foods and may be fattened as are other classes of livestock. The effect of feeding balanced rations is now being observed. It has been shown by the tests conducted at the station that the use of baled hay is not economical, since about 50 per cent of it is wasted. The use of prepared foods, such as alfalfa meal and molasses meal, is 50 to 60 per cent cheaper, since all the food is eaten and the freight cost is less. Records maintained indicate an annual requirement per head of 3 pounds of salt on ground feed or pasture, and 5 pounds on such dry feed as hay and grain.

CROSSBREEDING WITH CARIBOU

Crossbreeding of reindeer with caribou, including reciprocal crossing, has been successfully initiated. Six fawns from such crosses were born last spring at the station. Their average birth weight was 14½ pounds, a distinct net gain of about 5 pounds over that of the reindeer fawns, which average only 9½ pounds. Weighing showed that on an average these fawns double their weight in 15 days. Observations on the results of the caribou crossbreeding experiments made on Nunivak Island during the year also indicate gain in size as a result of the cross. The gestation period is 240 days. Normally does shed their horns

five to seven days after dropping the fawn, and variations in this respect indicate some abnormal condition. It is believed that the crossbreeding with caribou will prove of benefit not only in increased size but also in greater hardiness, spirit, and rustling ability. The caribou doe proves to be a better mother and better rustler than the reindeer.

REINDEER PARASITES AND THEIR CONTROL

Important information on the life history of the warble and nose flies affecting reindeer was obtained at the reindeer experiment station through the collection and rearing of grubs. This indicates that June 20 is about the most important date for control work, as it is the time of the last dropping of grubs and the first hatching of eggs. Information now available indicates that moving the herd at this time from the range where the fawns are born and where the last dropping of grubs occurs, to a summer pasture 15 to 20 miles away, will greatly reduce infestation.

Heavy infestation of reindeer by nose grubs greatly reduces their vitality and is at times fatal. The nose fly has been found to be an even greater menace to reindeer than the warble fly. The latter nevertheless is exceedingly troublesome, causing irritation and loss of condition, and the deposition of larvae of blowflies in the open wounds caused by warbles frequently results in the death of the animals.

INVESTIGATIONS IN ECONOMIC ORNITHOLOGY

LABORATORY INVESTIGATIONS OF THE FOOD OF BIRDS

Examination has been completed of all English sparrow stomachs on hand, a total of more than 8,000. This brings to a close laboratory work that has been in progress intermittently for nearly 10 years and makes available for study a mass of material far greater than has ever before been used in determining the economic status of a single species of bird. It is more than three times as great as the starling material used as a basis for Department Bulletin 868, and this was more than the combined material of all European investigators of this bird, including Collinge, Newstead, and Gilmour. This furnishes an idea of the relative scope of the English sparrow examination and that of studies of the food habits of other birds. The

indexing and tabulation of the items from the 8,000 stomach cards remain to be completed before the information will be in form available for publication. This is in itself a slow and tedious piece of work that will take months to complete.

During the year 1,555 stomachs and 61 pellets of birds were examined in the laboratory. The majority of these were from birds of prey, supplemented by the stomachs of English sparrows mentioned above, and of shore birds, bobwhites, crows, and other species. The birds of prey were of 32 species, and their examination marks an important step toward the preparation of a new bulletin on this economically important group. Among this material were several lots submitted by individuals and institutions interested in the status of these birds, including game officials of the State of Washington and of the Royal Ontario Museum of Zoology at Toronto, Canada. Examinations also were made of stomach material collected during the cooperative study of quail in Georgia.

FOOD OF OTHER VERTEBRATES

There were examined also the stomachs of 263 mammals of 18 species from six States and Alaska. Among them were stomachs of prairie dogs, deer, elk, seals, and a number of predatory animals. Examination of reptile and amphibian material included 109 stomachs of alligators, snakes of several kinds, and bullfrogs. In addition to the laboratory examinations of stomachs, work on the economic study of reptiles has been advanced by the issuance of a revised edition of a mimeographed circular on poisonous snakes. A popular article in the 1927 Yearbook discussed briefly the food habits and economic status of toads.

REPORTS ON INVESTIGATIONS

Manuscript for a farmers' bulletin on the European starling has been brought to date and at the close of the year was in the process of publication. There was published a technical bulletin (No. 24) on The Magpie in Relation to Agriculture, which dealt not only with the economic status of the bird, based on a study of its food habits, but also included suggestions for control measures where necessary. This bulletin responds to a long-felt need among ranchers, poultry raisers, and bird students in the West, where the magpie plays a rôle comparable

with that of the crow in the East. Farmers' Bulletin 755, Common Birds of Southeastern United States in Relation to Agriculture, was revised. The economic status of several of our birds that at times are in need of control was briefly treated in a mimeographed circular, issued for the use of field men of the bureau, and setting forth logical policies for the curtailment of damage, with a view to uniformity in handling matters of this kind throughout the country.

On the basis of field work in 1925 and 1926 and subsequent laboratory examination of about 1,300 stomachs, a manuscript has been prepared for a technical bulletin on the relation of blackbirds to the rice crop in the Gulf coast area. An article on Blackbird Control in Grain Areas in the 1926 Yearbook was also based largely on this investigation.

LOCAL STUDIES OF INJURIOUS AND BENEFICIAL BIRDS

CROWS IN ILLINOIS

For a number of years crows in southern Illinois have been inflicting severe damage on the corn crop raised on bottom lands adjacent to the Wabash and Ohio Rivers. Appeals have been made for aid in lessening these annual losses, and campaigns of wholesale destruction urged. Although reduction in the number of crows usually can be most economically effected during the winter months, when food scarcity tends to force these birds to take baits and enter traps, a study indicated that winter conditions in southern Illinois were not well suited for such operations. Light snowfall, little frost, and an abundance of food in abandoned or incompletely harvested fields of corn all conspire to make crow control there extremely difficult. So adverse were conditions that attempts to trap for banding even limited numbers of crows to determine individual migratory movements proved unprofitable.

BIRD ENEMIES OF CELERY PESTS

Study of the relation of birds to the leaf tyer and other insect pests of celery was continued in Florida in the spring of 1928. With the insects appearing in reduced, and thus more nearly normal, numbers than during the previous spring, the observations on the habits of birds were considered particularly valuable. Though less conspicuous work was done by palm warblers and tree swallows than dur-

ing the previous year, when there was a great abundance of the insect, these birds, together with bobolinks and red-winged blackbirds, were rendering excellent service in destroying celery pests. This is especially noteworthy, since in the South the two birds last named are themselves frequently regarded as pests where rice crops are ripening and being harvested.

BIRD ENEMIES OF CHESTNUT WEEVILS

In the first year (1926) of the project of increasing bird foes of chestnut weevils, carried on in cooperation with the Bureau of Plant Industry in the experimental chestnut orchard at Bell, Md., a total of 17 broods of birds was produced in the approximately 50 bird houses erected on a tract of 2½ acres. In 1927, with the same equipment, the number of broods rose to 40. In the spring of 1928 the nest boxes were doubled in number, and the experimental area correspondingly increased in size. The results attained up to the 1st of July with this added equipment gave indication of a still greater response on the part of the birds, one that can be fully appraised, however, only at the close of the nesting season.

WILD-FOWL DISEASE AND FOOD INVESTIGATIONS

DUCK MALADY IN THE WEST

Attempt was made during the summer of 1927 to diagnose the cause of duck mortality in southern Oregon, where on several occasions large numbers of ducks have perished under circumstances that indicated a cause other than alkali poisoning. The outbreak of the duck malady was too limited to permit a full investigation, but enough was learned to show that although alkali was present, it may not have been the sole cause. Evidence pointed to a possible combination of agencies, some of which may not have been present at Great Salt Lake, Utah, where, a few years ago, alkali was found to be the source of the trouble.

FOOD RESOURCES OF WILD FOWL

The survey of the wild-fowl food resources of the upper Mississippi River wild life and fish refuge has been completed as far south as Prairie du Chien, Wis. The past year's work included the surveying and reporting on fully 250 lakes and sloughs and the summarizing of data on some of the major areas of the refuge. Progress was

made also upon the survey of the very numerous lakes and marshes of the State of Minnesota, a project that will probably be completed in another season's field work. Reports on the work in former years in Montana, North Dakota, and Missouri still await publication.

Special investigations of the wild-fowl food resources were made in two localities in South Carolina, two in North Carolina, and one each in Georgia, Virginia, Michigan, and Ontario. The Virginia-North Carolina inspection related to Back Bay and Currituck Sound, localities over which sportsmen have been much concerned because of damage there by salt water to the food plants of wild fowl. The supply of wild-duck foods was found better than in other recent years, but consisted almost entirely of a single species, sago pondweed, which has considerable resistance to salt. Apparently the improved conditions noted are due mainly to heavy rainfall during the growing season, and the menace to Back Bay and Currituck Sound as winter homes for wild fowl will probably continue so long as there is a flow of salt water into them.

STUDIES OF OTHER GAME BIRDS

COOPERATIVE QUAIL INVESTIGATION

Excellent progress was made in all phases of the quail study being conducted in southern Georgia in cooperation with a committee of sportsmen interested in the betterment of quail conditions. A large part of the investigational work was concluded by March, 1928, though plans have been made to continue certain experiments and studies during part or all of the following fiscal year, at the conclusion of which it is planned to publish a final report. Analyses of the stomach contents of nearly 400 additional quail gave further insight into the food preferences of these birds, and this will assist in making recommendations for the propagation of suitable food-producing plants.

During the summer of 1927 every effort was made to perfect the "adoption system" of artificial quail propagation that has been used on a productive scale by five privately financed ventures in the vicinity of the field headquarters of this study. Eggs are obtained and incubated by the usual methods, but as soon as the chicks are hatched they are taken from the

bantams and given in batches of a dozen to 15 to cock quail that have previously been captured afield. The chicks are promptly adopted and cared for perfectly, and when a week old are released with their foster fathers. This system is proving to be an easily workable one under conditions prevailing on southern quail preserves.

Nesting studies of the quail were concluded late in the summer of 1927, bringing the total of nests studied up to 602. Results of this phase of the project have been already analyzed and will be detailed in the manuscript of the final report.

Considerable time was devoted to the study of the parasites of quail, especially intestinal parasites. Through a cooperative arrangement with the Bureau of Animal Industry a specialist was detailed for a period of approximately two months to the headquarters of the investigation at Beachton, Ga., where she studied the life histories of nematodes and cestodes prevalent in quail. One of the field assistants of the investigation spent some time also on the Virginia State game farm to observe the diseases and parasites of the young birds.

As the investigation is nearing its close, the banding of quail has been largely discontinued. Approximately 100 returns of banded quail were reported during the year as a result of shooting or trapping, and additional information obtained as to the movement of both the native and the introduced Mexican quail.

PROPAGATION OF GAME BIRDS

Two game farms were inspected during the year, and a preliminary manuscript revision was made of the Farmers' Bulletin on Propagation of Game Birds. It is planned to issue the new publication in two parts, one devoted to the upland game birds and the other to the aquatic. Findings from last year's study of methods used in game-bird rearing establishments in Europe have been incorporated in the new reports, and three other manuscripts on species suitable for introduction, on duck ponds, and on systems of game management, based in part on information obtained during the European investigations, have been prepared for outside publication.

INTRODUCTION OF GAME BIRDS

In addition to the bulletin issued to summarize information on wild birds introduced or transplanted in North America, a manuscript was prepared on game birds suitable for introduction into the United States. These reports cover both historical and current theoretical and practical aspects of a problem that is of great interest, particularly to sportsmen.

INVESTIGATIONS OF FUR RESOURCES

CONSERVATION OF FUR ANIMALS

Various constructive conservation programs are serving to maintain many fur animals in the wild. State and other programs have accomplished a great deal, but much remains yet to be done. In performing its part in this work the Bureau of Biological Survey has sent specialists to attend a number of meetings in various parts of the country of societies interested in fur animals and other wild life, and these have made special effort to put before the public the need of well-systematized fur-protective activities. The characteristics of various fur animals, their relative abundance, and their distribution have been brought to the attention of the fur trade by a series of monthly articles in the official organ of the National Association of the Fur Industry. Information of an educational nature has been distributed in cooperation with this association in the form of a booklet for school use that describes the life habits and utility of various animals for fur. Lantern-slide lectures and radio talks also were given. In the introduction to Farmers' Bulletin No. 1552, Fur Laws for the Season 1927-28, it is pointed out that our natural fur resources are steadily diminishing.

FUR-FARMING INVESTIGATIONS

Along with the nation-wide effort to conserve wild life, the raising of wild animals in captivity has continued to grow. It has been evident during the past year even more than previously that fur farming is rapidly developing into a stable, sound, and businesslike industry. Not all fur animals are suitable for raising in pens, but attempts have been made with most of them. A leaflet entitled "Recommendations to Beginners in Fur Farming," first issued in mimeographed form, has been prepared for general distribution.

FUR-FARMING IN ALASKA

Under an agreement between the Governor of Alaska and the department, work among the fur farmers of Alaska is being conducted by a veterinarian selected by the Biological Survey with a view to the betterment of conditions. The veterinarian inspects as many fur farms as possible, maintains contact with fur-farming projects under extremely varied conditions, and furnishes specialized information to the ranchers. His efforts are particularly directed toward more efficient methods of feeding, control of diseases and parasites through sanitation and treatment, and improving housing conditions.

DISEASES OF FUR ANIMALS

The concentration of large numbers of foxes and other fur animals on small areas has given the infectious diseases to which these animals are subject the opportunity to assume epizootic proportions, and heavy losses on some farms have been encountered. In an effort to be of the greatest assistance to fox ranchers in controlling these outbreaks it was necessary to study the causative organisms, the progress of the diseases, and protective measures. A 5-year cooperative agreement was entered into with the University of Minnesota, where considerable work on this project had been already in progress. The facilities provided at the medical school of the university have enabled the workers to observe epizootics on several ranches in that part of the country from the time of their onset to their termination. Several hundred foxes were given detailed post-mortem examinations, and laboratory studies were made of practically all the organs of the body, together with the pathogenic organisms obtained.

Two distinct infectious diseases of high virulence are recognized in foxes, and preliminary tests indicate the possibility of immunizing the animals. A preliminary nontechnical presentation of the parasitic and other diseases of foxes, including the so-called distemper, appeared in the 1927 Yearbook of the department. Further tests on a large scale are in progress.

FUR ANIMAL EXPERIMENT STATION

At Saratoga Springs, N. Y., the Bureau of Biological Survey maintains its fur animal experiment station, where extensive experiments on methods and practices in raising vari-

ous fur animals in captivity have been conducted. Before the establishment of the rabbit experiment station at Fontana, Calif., studies had been begun at the fur animal experiment station to determine the relative rate of growth of young rabbits of different breeds on various rations. Weights were recorded at intervals of a few days to learn the ages at which the most rapid growth was made and the most profitable development reached. Differences in climate, food, and other factors in the two sections will afford considerable comparative data for use in making recommendations on the management and care of rabbits.

Studies have been continued of the various factors influencing the quality of pelts of foxes, including comparisons of rations and changes in management. The influence of diet on breeding animals was studied, and certain significant facts were developed that may explain the frequent failure of foxes to reproduce. A mimeographed leaflet entitled "Feeding Vixens and Pups," made available for distribution during the year, describes the feeding methods recommended.

Crosses of various strains of foxes were made with the view to determine means of avoiding objectionable features in the offspring and the possibility of fixing desirable qualities. This project was somewhat handicapped by lack of animals of the necessary quality. It is desirable that several foxes having the desired characteristics be obtained to supplement the stock now on hand.

The silver fox is the principal species being raised in captivity for its fur alone. During this year the importations of foxes from Canada showed a decided decrease. On the other hand, a number of large exportations of silver foxes as well as other animals were made to various European countries. For the information of an increasing number of interested persons, a leaflet (No. 8) entitled "Mink Raising," was published during the year, and a mimeographed leaflet, *Raising Raccoons*, also was issued. The raccoon, marten, skunk, and muskrat seem tolerant of captivity, but it is questionable whether the muskrat and some of the others can be profitably raised under pen conditions. A growing interest in the raising of muskrats on natural marsh areas is resulting in frequent calls for advice regarding their food plants, the type of marsh land best adapted for their use, and habits, enemies, and diseases. Mimeographed

leaflets on the care of ferrets and on the care of white mice and rats were revised and reissued to supplement correspondence.

Karakul sheep are being raised in different parts of the country, and investigations indicate that they will become a valuable addition to the group of animals raised under fenced conditions for their pelts.

Rabbits are among the most numerous of fur animals now being raised in captivity, the distribution of the industry including every State. They are raised for a twofold purpose, as they can be utilized both for food and for fur.

Parasitic diseases, which in some degree are common to practically all fox ranches, have been given special attention. Since almost every animal must be treated a number of times during its life for worms, fleas, or mites, it is important that the simplest and most efficient methods be determined. Lungworms appear to be increasingly numerous and widespread in this country, and a satisfactory treatment for them has not been developed. Attempts at mechanical removal of these worms from the trachea have been made, in most cases successfully, and the animals were partially relieved. This method, however, is far from ideal, and further investigations are planned.

Studies have been made of the breeding habits of martens in captivity, and five additional animals have been purchased for experimental work. A progress report on the marten-breeding experiments of the survey was prepared in the bureau and published in November in the *Journal of Heredity*. A leaflet (No. 6), briefly stating the history and location of the experiment station and its chief accomplishments, was published early in the year, under the title "Experimental Fur Farm of the Biological Survey."

RABBIT EXPERIMENT STATION

The recent extensive development of the rabbit industry in this country led to a cooperative project at the close of the preceding fiscal year between the department, the National Rabbit Federation, and a local corporation interested in raising rabbits, for the maintenance of a rabbit experiment station at Fontana, Calif. The station consists of 5 acres of land, on which is a residence, an administrative building with offices and laboratory, rabbit buildings, hutches, and

other equipment. It was furnished and stocked with rabbits at the expense of these cooperators of the department. The station is now being operated by the Bureau of Biological Survey, and attempts are being made there, as well as at the fur-animal experiment station in New York, to ascertain the most economical and practical methods of feeding, housing, and raising the various utility breeds of rabbits. Leaflet No. 15, Rabbit-House Construction, and No. 22, Chinchilla Rabbits for Food and Fur, were published to facilitate the distribution of information called for along these lines.

RESEARCH IN ERADICATION METHODS

Predatory animals, such as coyotes, wolves, mountain lions, and bobcats, have been the cause of millions of dollars loss every year to livestock in the so-called range States ever since the time of the early settlers. Beneficial forms of wild life also have suffered by the depredation of these animals. Enormous losses also have been inflicted on agricultural crops by such injurious rodents as prairie dogs, ground squirrels, jack rabbits, field mice, pocket gophers, and rats—not only in the western agricultural regions, but in the East also, where many of these rodents, such as field mice, woodchucks, and rats, have given the farmer much concern and still cause great loss.

ERADICATION METHODS LABORATORY

Investigational work for the development of improved and economical methods in control operations against these destructive animals was conducted throughout the year at the eradication methods laboratory maintained by the bureau at Denver, Colo. Much information was gained on the efficiency of the various poisons employed, and control methods were improved. Particular attention was given to the use of thallium sulphate as a poison, and to the various compounds of strychnine, both in sulphate and alkaloid form. Reports on the characteristics and use of red squill and thallium sulphate in the control of injurious rodents were completed for publication as technical bulletins.

LEADERSHIP IN WILD-LIFE CONTROL

During the last week of April a conference of leaders in rodent and predatory-animal control was held at Ogden,

Utah, the first meeting of the kind since 1919. Of outstanding importance among the accomplishments was the development of detailed policies to be followed in the conduct of control operations, including preliminary research work. When fully operative, this will effect considerable economies of time and funds, and even before the close of the year it had permitted an extension of control work without increased financial resources.

Other definite recommendations made at the conference will mean considerable improvement in the laboratory and field methods. Realignment of the present personnel in keeping with these recommendations will permit the employment of an administrative officer for the laboratory, an experienced pharmacologist, and five field investigators. The extension thus made possible in the personnel of the eradication-methods project will centralize investigational work in control methods, thus giving district leaders more time for actual control operations.

At the conference of field leaders the policy to be followed was definitely stated to be one of control of injurious wild life rather than of eradication. The fact remains that the bureau must work for the eradication of certain species locally where their destructiveness is so impressive that no other policy of handling them is permissible. For example, the gray wolf and the prairie dog are so deleterious to agriculture and stock raising that their presence in some localities can not be tolerated. Other species, such as the coyote and the ground squirrel are so prolific and occur over such wide areas that their extermination, even if desired, would be impossible. The Bureau of Biological Survey is not embarked upon a general extermination program, and the main objective is so to control the predatory animals and rodent pests as to reduce economic losses to a minimum.

COOPERATIVE CONTROL OPERATIONS

The importance of controlling injurious wild-mammal pests can not be overemphasized. The Bureau of Biological Survey has been constantly called upon for additional assistance in control operations, but the resources at its disposal have not permitted an extension of cooperative work. No request for assistance received during the year, however, has failed to receive attention—the individual was given assistance either through correspondence or by actual field demonstration. It

is becoming more noticeable each year, however, that if control measures as developed by the Bureau of Biological Survey are to be effective, it is imperative to get into close touch with all possible cooperators and to furnish them with expert assistance. Increased personnel throughout the country is desirable to meet the demands for leadership of this kind. Trained leadership in field operations has been a great factor in the development of efficient hunters, trappers, and poison operators.

COOPERATIVE FUNDS AVAILABLE

Federal and cooperative funds available during the year permitted organized field work on the control of predatory animals and injurious rodents in 18 States. Federal funds totaled \$477,880, of which \$22,718 was used in research work at the eradication methods laboratory; \$278,939 in control of predatory animals; and \$176,223 in the control of rodents and other small animal pests. Cooperative funds from 14 of these States aggregated \$347,556, and in addition, cooperating counties, livestock associations, and individuals within the respective States raised \$679,065, making a total of \$1,026,621 in cooperative funds, of which \$432,359 was expended for the control of predatory animals, and \$594,262 for rodent control. Approximately \$1,481,773 was used in control operations under the leadership of the Bureau of Biological Survey, of which \$455,162 was from the Federal Treasury. Table 1 gives a

summary of cooperative funds used during the year.

PREDATORY-ANIMAL CONTROL

Greatly extended operations are essential in the range States, if the problems in predatory-animal control are to be solved. That the stock interests in these States look to the Federal Government for more adequate and equalized expenditure is evident from the annual resolutions of State livestock associations as well as correspondence received from hundreds of private stockmen. The Federal Government should provide more adequate financial support whenever practicable, particularly since there still exists in large numbers on the Federal domain a heavy infestation of predatory animals, which eventually invade private and State lands and are taking a \$20,000,000 annual toll from the producers of livestock and poultry.

WOLVES AND COYOTES

At the request of the Governor of Alaska, following an appropriation of \$10,000 for the purpose of cooperation with the Bureau of Biological Survey in predatory-animal control, one of the bureau's experts was detailed to the Territory to make a study of the best method of attacking the predatory-animal situation there. Wolves and coyotes in Alaska are committing serious depredations on deer, mountain sheep, fur bearers, and on many of the game birds, including ducks and ptarmigans.

TABLE 1.—*Cooperative funds made available for use in campaigns against wild animal pests in cooperation with the Bureau of Biological Survey*

States	Rodent work			Predatory-animal work			Total rodent and predatory-animal work		
	State	Other sources	Total	State	Other sources	Total	State	Other sources	Total
Arizona.....	\$14,999	\$67,758	\$82,757	\$14,998	\$1,163	\$16,161	\$29,997	\$68,921	\$98,918
California.....		259,890	259,890	19,966	46,970	66,936	19,966	306,860	326,826
Colorado.....	605	12,874	13,479	497	22,734	23,231	1,102	35,608	36,710
Idaho.....	4,436	22,951	27,387		17,434	17,434	4,436	40,385	44,821
Kansas.....	12,901		12,901				12,901		12,901
Montana.....		25,914	25,914	25,476	4,774	30,250	25,476	30,688	56,164
Nevada.....	1,499		1,499	16,980		16,980	18,479		18,479
New Mexico.....	27,548	15,279	42,827	35,406		35,406	62,954	15,279	78,233
Oregon.....	10,476	5,535	16,011	19,074	19,944	39,018	29,550	25,479	55,029
South Dakota.....		1,242	1,242	15,195		15,195	1,242		16,437
Texas.....	6,134	37,002	43,136	24,782	50,543	75,325	30,916	87,545	118,461
Utah.....	5,045		5,045	30,355		30,355	35,400		35,400
Washington.....	2,879	31,431	34,310	36,148	2,199	38,347	39,027	33,630	72,657
Wyoming.....	5,268	18,866	24,134	16,889	10,832	27,721	22,157	29,698	51,855
Eastern United States.....		3,730	3,730					3,730	3,730
Total.....	91,790	502,472	594,262	255,766	176,593	432,359	347,556	679,065	1,026,621

Predatory-animal control operations were carried on in all the States from Montana to Texas and westward, and also in South Dakota. Organized co-operative work was inaugurated before the close of the year in Oklahoma and Arkansas, States in which wolves as well as coyotes are causing severe depredations on wild game, domestic stock, and poultry. Coyote control was carried on to a limited extent also in southwestern Kansas and on the Niobrara Federal game reservation in Nebraska. In illustration of the success of the work it may be cited that in western Colorado one woolgrower, who lost 60 lambs and 8 ewes during lambing operations a year ago, states that on account of control work of Biological Survey hunters on this particular range, during the past year he lost only 1 lamb. He stated also that he had enjoyed the added advantage of being able to let his ewes and lambs run loose without molestation.

In Coos County, Oreg., the county agent reports an increase in sheep of more than 300 per cent, due entirely to the control of coyotes by poisoning methods conducted by the survey. Likewise, in Josephine County, Oreg., the county agent cites a substantial increase in the turkey business since the inauguration of coyote campaigns there. Forty-eight stockmen in 16 counties in Utah report greatly reduced coyote depredations on their ranges as a result of the work of survey hunters. In one Texas county a Biological Survey hunter killed a female wolf that within a year's time had destroyed \$5,000 worth of registered sheep and goats. In another county two wolves responsible for a \$2,000 loss in livestock in 12 months, as well as a female coyote that had caused a loss of \$1,200 by similar depredations, were killed.

The coyote is probably the most aggressive of the predatory species and continues to present the major predatory-animal problem on western cattle and sheep ranges. It can maintain itself in the face of advancing civilization and through the persistent warfare conducted against it by inexperienced individuals, it is becoming wary of man's traps. As a result, control is extremely difficult in certain sections of the West. The coyote is a prolific breeder, and often an area in which complete control has been attained may become reinfested in a very short time. During the past year more complaint than heretofore has been received from cattlemen of losses

of young calves by the coyote, one ranchman near Greenland, Colo., reporting the destruction of 100 young calves through its depredations. Such ground-nesting birds as grouse, ducks, and quail also are its constant victims. The control of this predator in areas of heavy infestation is possible only by coordinated action of Federal, State, and private agencies.

The gray wolf is under control in all States west of the one-hundredth meridian. The small red wolf of eastern Texas, however, is still the cause of severe depredations on livestock, but marked progress toward its control has been made during the year.

The total number of coyotes destroyed during the year, for which skins or scalps were actually obtained, was 35,709; gray wolves, 11; and red wolves, 716. In addition, it is estimated that 48,000 coyotes were destroyed by the use of poisons but not recovered.

MOUNTAIN LIONS

Biological Survey hunters disposed of 219 mountain lions during the year—18 in Utah, 17 in Oregon, 23 in Montana, 38 in New Mexico, 108 in Arizona, and 15 in other States. In Arizona the figure given brings the grand total of mountain lions killed in the State in 12 years to 910.

BEARS

In the course of the year it became necessary to kill 226 bears known to prey on livestock. Bears in general are not predatory in their habits and are usually classed as game. Individuals, however, that become predatory must be destroyed. The policy of the Biological Survey regarding the bear is to establish definitely that an individual has become addicted to stock-killing before it is considered predatory. The policy was detailed in a popular article, *Bears Sometimes Unjustly Blamed as Stock Killers*, prepared in the bureau and published in the 1927 Yearbook.

In Alaska the large brown and grizzly bears are classed as game animals and may be taken legitimately only during open seasons. The black bear is classed as a fur animal and may be taken in the open trapping season throughout the Territory except in the northern part of fur district No. 2, where, because of local depredations, it may be taken at any time. There has been, and still is, some complaint regarding the menace of the Alaska

brown bear and the grizzly to life and property. The regulations under the Alaska game law concerning the taking of these animals provide that "any person may kill a large brown or grizzly bear at any time when such animal is about to attack or molest persons or property, or when found within half a mile of a residence or human habitation."

It is felt that this regulation gives wide latitude to those who may encounter dangerous or destructive individuals of the species in question. In general, the testimony from reliable sources throughout Alaska is to the effect that the large brown and grizzly bears, with but few exceptions, avoid mankind as much as possible and that mauling or actual killing of human beings by unmolested bears rarely occurs.

BOBCATS AND CANADA LYNXES

Bobcats and lynxes are the source of considerable loss to livestock, especially to sheep during the lambing season, but are readily brought under control by trained hunters. During the year 4,838 bobcats and 40 lynxes were taken in the States in which predatory-animal control was undertaken by the bureau.

CONTROL OF RODENTS AND OTHER SMALL MAMMALS

Organized rodent-control operations were carried on during the year under the leadership of the Biological Survey in 18 States, and educational work in 10 others. The operations benefited several Eastern States, including North Carolina, which was this year added to the list.

In the field operations 3,306,000 pounds of poisoned bait, 141,580 pounds of calcium cyanide, and 626,463 pounds of carbon disulphide were used in controlling rodent pests on 14,545,591 acres of land. Besides other poisons, more than 88,000 ounces of strychnine were used in preparing bait, of which 74,000 ounces were purchased through the bureau from the manufacturers at a saving to cooperators of approximately \$37,000. The saving under this plan allowed the cooperative funds available to be used in more extensive operations.

Control work was carried on in cooperation with such other agencies as agricultural colleges, State departments of agriculture, county agricultural agents and other county officials, and farmers' and stockmen's associations;

and with the Extension Service and the Forest Service of this department; the Office of Indian Affairs and the Bureau of Reclamation, of the Interior Department; and with individual farmers and stockmen. The cooperation received from these agencies, including work, materials, and money, is very gratifying, the funds being more than three times the amount expended by the bureau from Federal appropriations.

The importance of the results may be judged from replies to a questionnaire mailed to 4,018 cooperators in one State. These estimated that as a result of the year's work in rodent control in that State alone there was a saving in crops, range grasses, and fruit trees of \$474,235.

Rodents are of numerous species and they are so widely distributed that uncontrolled their damage to farm crops and forage would be appalling. A comprehensive rodent-control program, more drastic than present funds permit, is called for. Much has been accomplished, but very much remains to be done.

GROUND SQUIRRELS

Ground squirrels of various species are generally distributed over the area west of the Mississippi River, and in Wisconsin, Illinois, Michigan, and Indiana. Their destructiveness to agriculture consists mainly in damage to growing grain, forage crops, and garden vegetables. Practically every crop grown on the farms in the infested areas is subject to damage by them. In irrigated sections they also burrow through the embankments of canals and dams and cause their destruction and the ruin of crops on adjacent agricultural lands. Much loss is sustained also in their consumption of forage on the open ranges. According to signed statements made by 4,037 farmers in one Western State alone, during the years 1918, 1919, and 1920, there would have been a total annual loss from ground squirrels of \$2,087,742 in farm crops on 638,971 acres, or an average of \$3.26 an acre, practically all of which was prevented by the cooperative work with the survey. Estimates obtained this year from farmers in various localities of Montana, where the infestation averages five or more ground squirrels to the acre, indicate that each ground squirrel can destroy during a season 75 cents worth of grain, or at the rate of \$3.75 an acre.

The Biological Survey carried on campaigns to control the depredations of ground squirrels in all States west of the Great Plains, and in Kansas and South Dakota. Excellent financial and other cooperation was received, and in most cases losses in agricultural crops were kept at a minimum. In this work 2,690,479 pounds of poisoned bait, together with 119,868 pounds of calcium cyanide and 610,580 pounds of carbon disulphide, were used on a total of 11,104,749 acres. Of these quantities 103,715 pounds of poisoned bait were furnished by the bureau and used on 862,731 acres of Federal land, most of which was on national forests and other public domain.

The destruction of ground squirrels on public domain adjacent to private holdings is of great importance in many localities in the West. These Federal lands are a center of infestation, and if the pests are not controlled there, permanent relief is impossible on adjacent property. The bureau is handicapped in its work on Federal lands by lack of sufficient funds, and only a comparatively small acreage now infested can be treated.

One of the real accomplishments in cooperative ground-squirrel control during the year was the establishment of a central bait-mixing station in the Idaho district, similar to smaller stations that have been in operation in other districts. Such a station assures a district good poisoned bait uniformly mixed, and makes available at all times adequate quantities at the lowest possible cost. Savings made possible by the central plant come from the use of machinery and low-priced labor on such routine work as mixing, sacking, and distributing, thus affording field leaders, county agents, and other cooperators more time for field work. The saving to the bureau and to the extension service in Idaho in time and reduced cost of materials amounted to more than \$3,000 for the season, in addition to savings effected for other cooperators. Between March 15 and June 30 more than 175,000 pounds of mixed bait were handled, and 75 per cent of it was delivered by truck direct to cooperators at various points in the State.

PRAIRIE DOGS

Prairie dogs of several species are distributed over the Plains States and westward to the foothills of the Rocky Mountains, as well as in Utah, New Mexico, Colorado, and Arizona. They

cause serious loss in farm crops, but probably inflict the greatest damage on range forage. In control operations 463,049 pounds of poisoned bait, 2,960 pounds of calcium cyanide, and 5,000 pounds of carbon disulphide were used on a total of 2,484,011 acres in Arizona, Colorado, Kansas, Montana, New Mexico, South Dakota, Texas, Utah, and Wyoming. In this work 96,314 pounds of poisoned bait were used on 673,360 acres of Federal land. In several of these States extensive areas have been cleared of prairie dogs, resulting in a material saving to the livestock and farming industries. One stockman of Arizona reported that "poisoning prairie dogs on my range saved me about \$2,000 worth of grass." Another reported, "I estimate we saved over \$5,000 by clearing prairie dogs from 4,200 acres." Conditions regarding the treatment of Federal lands in the control of ground squirrels apply also in the case of prairie dogs.

JACK RABBITS

Jack rabbits inhabit practically all of the territory west of the Mississippi River and are responsible for considerable loss in farm crops, particularly in alfalfa and grain, and also in range grasses and fruit. In the Southwest they do considerable damage to cotton plants. During the winter they destroy hay in the stack, and in summer consume a large quantity of forage on the range. The heaviest damage occurs during periods of extended drought. That rabbits destroyed 40 tons of hay in the stack on one farm during a winter season is shown by court records in Lincoln County, Idaho. Midland County, Tex., alone records a loss of \$95,000 this year from reduced cotton yield from their depredations. In orchards the rabbits girdle the trees and eat the bark in winter, when other food is scarce.

Operations for the control of jack rabbits, conducted in 13 States during the year, resulted in the protection of large crop areas. An example of this protection is furnished in a report from one cooperator in Arizona as follows: "I estimate that you saved \$30,000 worth of cotton for us in this district by assisting us in poisoning jack rabbits." Many other reports of similar nature have been received.

A continuance of efforts begun last year by field men of the bureau to market wild-rabbit skins gave added impetus to the cooperative control of jack rabbits. During this year more

than \$160,000 was received in this way by cooperators in Colorado, Idaho, Kansas, Montana, South Dakota, Utah, and Wyoming. If a profitable market for these skins is maintained, the problem of controlling jack rabbits will to a large extent be simplified.

POCKET GOPHERS

Pocket gophers of various species are distributed over much of the United States and become a serious farm and orchard pest in many localities. They not only eat growing grain but cover much more of it with soil. Their burrows and mounds prevent close mowing and interfere with and break machinery, and their burrows in irrigation ditches result in deep gullies on sloping land, waste of water, and interference with its distribution. They cause costly breaks in dams and embankments of irrigation canals. An orange grove in Arizona was sold at a loss of \$10,000 because of damage by pocket gophers to the tree roots. The owner of another grove had his net annual income cut \$2,500 when he lost 250 trees from pocket-gopher work. A break in an irrigation canal near Gila Bend, Ariz., caused by pocket gophers, resulted in a \$35,000 crop loss and required nearly \$5,000 for repairs.

Cooperative campaigns for the control of pocket gophers carried on in 15 States afforded protection to large areas of forage and grain crops and fruit and forest trees, as well as to irrigation water. It is well to give typical examples of the protection afforded: An irrigation-district superintendent at Tucson, Ariz., reported, "We have poisoned pocket gophers on our irrigation project the past four years under the management of your assistant and have had splendid results. I would estimate the saving at at least \$4,000." A date grower reports an estimated saving of \$10,000 worth of date palms through pocket-gopher control work. A farmer says: "Saving from pocket-gopher poisoning on 540 acres estimated at \$1,200." On the Nebraska National Forest 14,000 acres of pine plantations were treated in co-operation with the Forest Service, and the damage by pocket gophers was checked, whereas in the past 25 years about a third of all trees planted had been killed by the rodents.

A two-reel motion-picture film, *Million-Dollar Pockets*, graphically depicting methods of coping with pocket gophers, was released during the year and has been shown in prac-

tically every State in which the bureau is conducting control operations. The film has stimulated great interest and has accomplished much in bringing before the public the necessity of destroying pocket gophers in localities where they are actively or potentially injurious.

FIELD AND HOUSE MICE

In addition to house mice, several forms of field mice are distributed over the whole of the United States, the degree of infestation varying to a great extent from year to year. During some years these rodents are scarce in certain localities in which in other years they increase to large numbers and inflict heavy damage to farm and orchard crops, in some cases ruining entire fields. The injury to field crops is brought about by mice eating the roots of the plants reached by their numerous burrows. The injury to fruit trees and shrubs consists in the destruction of the bark near the surface of the ground. When the girdling is complete and the cambium eaten through, the action of the sun and wind soon complete the destruction.

There are many cases in which 20 per cent or more of the trees in orchards are killed by mice. One orchard in Washington State suffered 50 per cent damage this season, and a heavy infestation of mice in Jones and Lyman Counties, S. Dak., was responsible for the loss of more than 40,000 acres of corn. Damage by house mice to grain in storage in warehouses of the northern Sacramento Valley, Calif., has been reported as amounting to \$100,000 for the year. The pine mouse, a species of field mouse, is exceedingly destructive to fruit trees and shrubs in the Eastern States and to a minor extent to bulbs and root crops also.

Field-mouse infestations of serious proportions were noted in California, Idaho, Oregon, South Dakota, Washington, Utah, and many Eastern States. Control was undertaken in the West in these States and in the East in North Carolina, Maryland, Maine, Pennsylvania, and Vermont. More than 53,000 pounds of poisoned bait were used in the Wenatchee and Yakima districts in Washington alone to control this pest.

BROWN RATS

The brown rat, introduced from the Old World and now established in ev-

ery State of the Union and the Territory of Alaska, is the most injurious of rodents. Feeding indiscriminately, it damages manufactured and other commodities and destroys all kinds of vegetable and animal matter, and at the same time contaminates large quantities of food. As a disease carrier the rat is a serious menace, and is responsible for deaths among human beings through its spread of bubonic plague and other infectious diseases.

An example of rat depredation that indicates the extent of its destructiveness and shows something of the extent of agricultural products concerned was furnished during the year in Galveston County, Tex. One fruit grower reported that rats ravished his berry patch to such an extent that instead of his being able to ship 115 lugs (boxes) of berries as he had the previous year, he could pick only 4 lugs this season. One farmer reported a loss of \$500 in sweet potatoes and turnips from 20 acres, and another reported a loss of \$60 in figs, \$1,500 in trees girdled, and \$100 in truck crops. Losses in watermelons, cantaloupes, tomatoes, carrots, beets, beans, and corn were also reported in the same county, one farmer stating that he lost \$1,000 in watermelons on 10 acres through depredations of rats.

Action in the control of rats has been undertaken during the year in 16 States in the form of organized antirat campaigns in cities and country districts or demonstrations showing methods of destroying this pest. Among the cities in which extensive antirat campaigns were conducted were Portland, Oreg.; Tacoma, Wash.; Oakland City, Ind.; Stevens Point, Wis.; and Sylva, N. C.

Notable among the campaigns in country districts was one in Texas organized in 54 counties. In the course of the work 22,200 pounds of barium carbonate were used in preparing poison baits, and prizes were offered to persons destroying the most rats. As a result 3,690,528 dead rats were counted in these contests. On the basis of the estimate of governmental and industrial experts that each rat will destroy from \$1.80 to \$2 worth of foodstuffs and other property in a year, this represents an immediate total saving of more than \$6,500,000 to Texas, the amount of property these rats would have destroyed if they had lived another year. In the campaign in Ellis County, Tex., with a population of less than 57,000 persons, 243,321

rats were destroyed in one month, probably a world's record.

Farmers' Bulletin No. 1533, *Rat Control*, issued at the beginning of the year, has been in great demand, and about 200,000 copies have already been distributed. A motion-picture film, *How to Get Rid of Rats*, also was released during the year and has been shown in practically every district of the United States where rats are injurious.

WOODCHUCKS

Woodchucks inhabit rocky places, woodlands, and bramble thickets, and from the nature of their habitat, come in contact with agriculture only in scattered localities. When their haunts are immediately adjacent to farm lands, however, they become a serious pest. In the East they appear to be more numerous in certain agricultural areas than formerly, and in many open fields are now burrowing far from their usual haunts. Woodchuck damage is diverse and affects many different crops and fruit trees, and particularly such forage crops as alfalfa, clover, and other legumes. In control measures undertaken in eight States poisoned baits and calcium cyanide as a fumigant were used. A leaflet (No. 21) entitled "Woodchuck Control in the Eastern States" was issued and has been widely distributed.

PORCUPINES

In the forested areas of the West the increase in numbers of porcupines is very evident, and much damage is done to trees. It is important that control measures be taken in many of the national forests to protect both the well-developed trees and the younger growth. Control operations were carried on in six States, the accomplishments in Oregon and Arizona being especially noteworthy, and considerable progress in methods of preparing poisoned baits was made during the year. A leaflet on porcupine control, based on field and laboratory research, is in preparation.

OTHER INJURIOUS RODENTS

Other injurious rodents, including the wood rat and the kangaroo rat, are responsible for considerable loss to agriculture in certain sections of the country. Where these rodents are numerous enough to be injurious, control measures have been recommended.

MOLES

Moles are found only in the Pacific coast region and in the eastern half of the United States. Where they burrow in such places as gardens, lawns, and fields, they are considered a pest because of the displacing of plants, covering of growing crops, the use of their runways by field mice, and the obstruction their mounds offer to the use of machinery. The damage caused by moles in bulb-raising areas in the Northwest is coming to be of considerable economic importance because of the rapid increase in this industry.

CONTROL OF ANIMAL-BORNE DISEASES

RABIES

Sporadic cases of rabies were reported and verified during the year in Oregon, being possibly the remnant of a heavy outbreak that occurred in that State in 1926. In Nevada, 14 positive cases were recorded, 3 in coyotes, 2 in bobcats, 5 in domestic cows, 2 in sheep, and 1 each in a domestic dog and a house cat. These cases indicate that rabies is still fairly well distributed over that State. Biological Survey hunters in Nevada took rabid animals from five counties, where some livestock was lost, but the spread of rabies was expeditiously suppressed in practically all cases. In Colorado during early spring a rabies outbreak of considerable proportions occurred in the area between the towns of Golden and Boulder, the disease being confined entirely to dogs, and so far as known not reaching predatory animals. Sporadic cases of rabies occurred in Washington, particularly in the eastern part of the State, but through effective co-operation of the Washington State Department of Health and the State college at Pullman it has been possible to detail hunters quickly to districts where outbreaks threatened and to utilize this expert personnel to reduce the number of predatory animals by the use of both traps and poison.

TULAREMIA

Tularemia among jack rabbits in South Dakota and among field mice in California was reported during the year, and measures of control were undertaken by the rodent-control force of the bureau.

BUBONIC PLAGUE

Two cases of bubonic plague among human beings have been reported in

Contra Costa and Santa Cruz Counties, Calif., one of which proved fatal. Positive cases of the plague were found in ground squirrels from these counties as well as in those from Alameda, San Benito, Monterey, and San Luis Obispo Counties. Special attention is being given in cooperation with State and Federal public health officials to checking the spread of the disease in the infested areas through reducing the ground-squirrel population.

MAINTENANCE OF WILD-LIFE RESERVATIONS

As civilization advances, the removal of forests and the drainage of marsh and water areas for cultivation and industrial purposes continues, and the necessity for establishing more reservations for migratory birds and big game throughout the United States increases proportionately. The refuge idea as a means of conserving valuable wild life is not new. It has already been well tested and successfully used in several States as a means of restocking depleted covers, and the steady increase of birds and animals on the Federal reservations during the year is further proof of the soundness of the system. It is now recognized that the refuge system or some extension of the principle is the only means by which the extermination of many of the valuable forms of wild life can be prevented in North America.

To be most effective, a game or bird reservation must be given constant attention by a resident protector, one who is thoroughly familiar with the area. Frequent patrols are necessary to prevent poaching and to control predatory animals or other natural enemies. The upkeep and increase of food plants and the checking of disease also are important functions of reservation protectors and require continuous attention and study.

Reservation administration falls within three recognized lines of activity: (1) The acquisition of lands for reservations; (2) the protection and maintenance of bird refuges and game preserves, and their wild life; and (3) restocking with suitable species. Land acquisition is now going forward on the upper Mississippi River wild life and fish refuge and the newly authorized Bear River migratory-bird refuge and requires the services of engineers, surveyors, and land valuation and purchase experts. Included in protection and maintenance of reservations is watchfulness for the welfare of the animals, improving the areas for their

use, and facilitating enjoyment by the public.

Reservations make it possible to restore to surrounding or similar areas indigenous forms of wild life that may have become extinct by reason of over-shooting or other causes. The utilization of surplus stock on reservations for transporting and planting elsewhere is increasing from year to year.

A list of wild-life reservations under the jurisdiction of the survey and of other branches of the Federal Government was published in the Yearbook for 1927, and recent changes are mentioned in this report. The total number under the jurisdiction of the bureau at the end of the year was 78.

BIG-GAME PRESERVES

Fenced preserves and other areas for big game under Biological Survey jurisdiction are the national bison range in Montana, the Niobrara reservation in Nebraska, the Sullys Hill game preserve in North Dakota, the Wind Cave game preserve in South Dakota, all of which are surrounded by game fence; and the winter elk refuge in Wyoming. No seriously adverse conditions at these reservations were experienced during the year. The approximate number of big-game animals on these reservations on June 30, 1928, is shown in the accompanying table.

NATIONAL BISON RANGE

It has been necessary to reduce the herds of buffalo and elk at the national bison range, Montana, in order to prevent overcrowding and the possibility of disease and starvation through natural increase. This reduction has been effected by the sale or gift of animals for stocking other ranges and for exhibition in public parks and zoological gardens throughout the country, and by slaughter and disposal for food pur-

poses. Twenty-three buffalo from this range were shipped to Alaska near the end of June in an experiment made by the Alaska Game Commission to establish a herd in the Tanana Valley, near Fairbanks, under funds appropriated for the purpose by the legislature of Alaska. The removal of the surplus animals will assist materially in the recovery of forage on the range, although some additional animals will have to be disposed of in order to bring the stock within safe bounds. The building of additional game fences will enable the preserve to carry a greater number of animals by permitting grazing by rotation. The herd of mountain sheep at the bison range has been increased by the birth of 14 lambs, bringing the total number of animals in the herd to 92.

WINTER ELK REFUGE

The winter was one of sufficient severity in western Wyoming to require, as in the previous season, the feeding of a heavy tonnage of hay to an increased number of elk visiting the feeding grounds. The first elk to enter the refuge was a lone bull on November 6; a week later 10 cows and calves came in, and 113 elk were counted on November 20. By the end of November about 2,500 elk were on the refuge and adjacent ranches, and during December and thereafter the number increased steadily. The snow averaged about 1 foot in depth at the end of December, and feeding the elk began on January 12 and continued to April 21. More than 9,000 elk were fed during the winter, a substantial increase over the maximum count of 7,549 the previous year. The total quantity of hay fed by the Federal and State governments was 3,460 tons, compared with 3,006 tons during 1927. The increasing numbers of elk visiting the refuge area emphasize the importance of plac-

TABLE 2.—*Big-game animals on reservations of the Bureau of Biological Survey, June 30, 1928*

Preserves	Buffalo	Elk	Antelope	Mountain sheep	Deer		Total
					White-tailed	Mule	
National bison range, Montana.....	459	¹ 190	—	92	¹ 34	¹ 150	925
Wind Cave game preserve, South Dakota.....	189	¹ 155	29	—	—	—	373
Sullys Hill game preserve, North Dakota.....	17	¹ 29	9	—	1	—	56
Niobrara reservation, Nebraska.....	90	¹ 106	10	—	1	—	207
Total.....	755	¹ 480	48	92	¹ 36	¹ 150	1,561

¹ Estimated.

ing a definite limit to the size of the Jackson Hole elk herd, and point to the necessity of providing more winter forage for a suitable number of animals if starvation in another severe season is to be averted.

Early in the fiscal year the Isaak Walton League of America transferred to the department satisfactory title to the 1,760 acres of land in Jackson Hole adjacent to the elk refuge, which the Waltonians had purchased, with a view to increasing the total area in the Government holdings.

The feeding of augmented numbers of elk during the past two winters reduced to a comparatively few tons the stock of hay that had accumulated during previous mild winters. Only about 195 tons remained on hand. The crop on the refuge this year will probably be about 1,500 tons. If next winter should be mild there is a possibility that the refuge hay crop, supplemented by hay purchased by the State of Wyoming, will suffice for the needs of the elk, but another very severe season would result in starvation on a large scale. To maintain and replenish the supply each season, it is important to increase the size of the refuge and thus make unnecessary emergency purchases of hay at high prices. Steps are being taken to increase production on the Government lands and to reduce the proportion of injurious squirrel-tail grass.

In accordance with a recommendation of the elk commission, a biologist familiar with big-game animals was detailed to a study of the life history and needs of the elk. The results of work already accomplished are dealt with under another heading. The elk commission recognized the necessity of acquiring additional land adjacent to the present refuge to insure adequate winter-feeding facilities, and recom-

mended appropriate Federal legislation. A bill introduced in Congress in December to provide for the enlargement of the elk refuge contemplated the acquisition of about 12,000 acres of suitably located land under an appropriation of \$275,000. This bill received the approval of the Bureau of the Budget to the extent of authorizing an appropriation of \$150,000, with the proviso, however, that this amount would be available only in case an equal amount in subscriptions or land were contributed by the State, counties, organizations, or individuals. The bill still awaits congressional action.

OTHER BIG-GAME PRESERVES

Including three fawns born to the antelope at Niobrara reservation in Nebraska during the year, there are now 10 of these animals at this preserve. The antelope band at Wind Cave preserve, S. Dak., was increased to 29 by the birth of 7 fawns. An 80-inch game fence, which will inclose approximately 4,000 acres of additional rugged land, was brought nearly to completion on the Wind Cave preserve. Five and one-half miles of stock fence also were completed at the elk refuge in June.

UPPER MISSISSIPPI RIVER WILD-LIFE AND FISH REFUGE

Land-acquisition work on the upper Mississippi River wild-life and fish refuge continued. Progress was considerably hampered, however, because of the average price limit of \$5 an acre fixed by the legislation that authorized the establishment of the refuge. Many tracts that could not be purchased have been leased with the object of purchase, and this action has assisted in controlling the situation. The present Congress, however,

TABLE 3.—*Young of big game born on reservations of the Bureau of Biological Survey during the calendar year 1927*¹

Preserves	Buffalo	Elk	Antelope	Mountain sheep	Deer		Total
					White-tailed	Mule	
National bison range, Montana.....	118	80	-----	20	5	50	273
Wind Cave game preserve, South Dakota.....	31	14	4	-----	-----	-----	49
Sullys Hill game preserve, North Dakota.....	5	9	-----	-----	-----	-----	14
Niobrara reservation, Nebraska.....	11	18	2	-----	-----	-----	31
Total.....	165	121	6	20	5	50	367

¹ Including some data published in the report covering the fiscal year 1927, the change from fiscal to calendar year being in the interest of greater accuracy in the compilation of figures. Some figures in the text of this report are for the fiscal year.

has authorized the payment of a maximum average price of \$10 an acre, and this will facilitate future acquisitions. Joint regulations for the administration of this refuge, as approved June 24, 1927, by the Secretary of Agriculture and the Secretary of Commerce, were issued in July (S. R. A.—B. S. 67), by the Biological Survey, to cover such matters as wild-life protection, fire prevention, and recreational uses of this important area, and have proved adequate.

A resolution recently passed by Congress authorized the acceptance of title to about 488 acres near the city of McGregor, Iowa, donated by James Buell Munn, of New York City, as an addition to the refuge. A large part of this area was not subject to overflow, but will be useful for observation and administrative purposes, and congressional consent was necessary to acceptance. The lands are valued at between \$30,000 and \$40,000.

OTHER IMPORTANT REFUGES FOR BIRDS

BIG LAKE

Big Lake bird refuge, in northeastern Arkansas, which was deep in water during the flood period of 1927, was visited by an even greater flood this year. The levees around the refuge were threatened, and at one time the water had risen to the tree-tops on certain areas. Late in June the entire refuge was still under water.

MALHEUR LAKE

At Malheur Lake bird reservation, in eastern Oregon, the water has been higher than for a number of years, with resultant benefit to the waterfowl and growth of their food plants. There appears to be promise that for the first time in four years the young pelicans hatched on the reservation will safely reach maturity.

NEW AND ABANDONED RESERVATIONS

MATANZAS, PATHFINDER, AND UPPER KLAMATH ESTABLISHED

During the year three new reservations were established: Matanzas Bird Refuge, Fla., August 10, 1927; Pathfinder Bird Refuge, Wyo., April 19, 1928; and Upper Klamath Wild-Life Refuge, Oreg., April 3, 1928. The Upper Klamath refuge consists of 5,200 acres of marshland along the west side of the lake of the same

name. It is of considerable importance to the waterfowl of the region, in view of the wholesale drainage of marsh areas for agricultural purposes, and especially the practical elimination of Lower Klamath Lake, embracing about 80,000 acres, and formerly one of the most important breeding and resting grounds for migratory waterfowl in western North America.

BEAR RIVER REFUGE AUTHORIZED

The outstanding feature of the year in reservations was the approval on April 3, 1928, of an act of Congress providing for the establishment of the Bear River migratory bird refuge on the marshes at the mouth of Bear River, Utah. The legislation authorized an appropriation of \$350,000, of which \$200,000 was made available to initiate the work and carry it through the fiscal year 1929.

Through the construction of a system of low dikes, fresh water from Bear River will be impounded over tens of thousands of acres, mainly barren mud flats bordering the present shore of Great Salt Lake. The creation of a refuge in this locality through a system of dikes has several objectives: The spreading of fresh water over the broad salt-impregnated mud flats will end the appalling losses of waterfowl, especially ducks, through so-called alkaline poisoning. It is estimated that in the past few years not less than 7,000,000 ducks have perished from this cause alone within and adjacent to the area to be included in the refuge. It has been found that aquatic vegetation providing an abundance of food for waterfowl grows amazingly in water so impounded, and thus a poisonous death trap for the birds will be converted into a great feeding and resting ground for a host of migrants which in their overland flight, as shown by bird-banding operations, visit points in neighboring States as far west as California. The construction of the dikes will also greatly increase the breeding areas for resident waterfowl and prevent the periodical invasion of salt water due to slight rises in the level of Great Salt Lake. In 1924 an inundation of this sort destroyed thousands of acres of fresh-water marsh in the Bear River Delta, thus contributing very materially to the adverse conditions.

Under the new law not less than 60 per cent of the area is to be maintained as an inviolate sanctuary for migratory birds, the remainder being subject to

possible use as public shooting grounds under regulation. Much of the area involved consists of national domain or of lands that will be added through the cooperation of the State, but some areas must be purchased. Active steps are being taken to initiate the land-acquisition and engineering work.

MOSQUITO INLET REFUGE DISCONTINUED

The Mosquito Inlet bird reservation, near New Smyrna, on the east coast of Florida, became of little value to birds owing to the growth of the town and consequent question of jurisdiction. An Executive order abandoning the refuge was accordingly issued on March 17.

RECREATIONAL USES OF WILD-LIFE RESERVATIONS

Designed primarily to prevent the extermination of numerous valuable and interesting species or to extend to them needed protection, some of the wild-life reservations afford unusual opportunities for recreational enjoyment by the public and for scientific observation and study. Many kinds of wild life are essentially shy and retiring and to thrive must be granted seclusion. This is especially true of bird colonies during the breeding season. The big-game preserves, however, afford places where the public can enjoy the sight of wild animals at short range. Public interest in such recreational advantages is shown by the increasing number of visitors to some of the larger and better-known reservations. This public appreciation is gratifying, although the presence of visitors adds to administrative burdens, and funds are lacking to provide properly for their comfort and safety. The Sullys Hill game preserve, near Devils Lake, N. Dak., continues to attract an increasing number of visitors. During the year 23,233 persons and 4,903 visiting automobiles were recorded, taxing to the utmost the available facilities.

In addition to affording protection to wild life, the upper Mississippi River wild life and fish refuge will ultimately furnish opportunities for public recreational uses at many points. These will include camping, fishing, and even public shooting on certain areas. On parts of the navigable waters and meandered lakes within the upper Mississippi refuge, hunting of waterfowl was permitted during the 1927 season in accordance with State laws and the regulations under the migratory-bird treaty act. Public

shooting of migratory game birds is permitted also on a part of the Big Lake bird reservation, Arkansas, and on other refuges where limited hunting will not defeat the purpose for which they were created.

URGENT NEEDS OF RESERVATIONS

Additional funds are required for the proper maintenance of many of the game and bird reservations. During recent years appropriations have permitted the carrying out of only the most vitally necessary improvements and repairs.

ALEUTIAN ISLANDS RESERVATION

The Aleutian Islands bird reservation extends in a chain for about 800 miles southwestward from the end of the Alaska Peninsula. It embraces many large and small islands on which the status of wild life is but imperfectly known. Requests for permits to use some of the islands for sheep raising, fur farming, and other commercial developments require careful consideration to protect the wild life and safeguard the interests of the natives who are dependent upon the island resources for their livelihood. As soon as funds can be made available a regular warden service should be established and a seaworthy vessel provided to patrol the area. A comprehensive survey of the wild life of the reservation and conditions affecting it is needed as a basis for efficient administration.

HAWAIIAN ISLANDS RESERVATION

The Hawaiian Islands bird reservation includes widely scattered islands far out in the Pacific Ocean northwest of Hawaii, constituting as a whole a group of surpassing interest from the wild-life standpoint. Certain of the islands are the natural homes of birds found nowhere else. Some of these birds have become extinct, while others, including the Hawaiian teal, have been so greatly reduced that they are not likely long to survive without special protection. The islands provide breeding places for large colonies of albatrosses and other interesting sea birds, and thus invite raids by poachers and trespass by fishermen. At one time rabbits were unwisely introduced on to some of the islands, and on Laysan, the most important of the group, these rodents so destroyed the vegetation that most of them starved. The destruction of vegetation produced conditions very unfavorable for bird life.

Efforts to eradicate the rabbits with a view to making the vegetation available to the birds have apparently been successful. Two wardens should be placed on Laysan Island and provision made for regular visits to the other islands.

SAVANNAH RIVER BIRD REFUGE

Of particular importance as a haven for certain rare and valuable migratory birds is the Savannah River bird refuge in South Carolina. Thousands of the rare and beautiful wood duck—near extinction a few years ago—nest there. It is made up of abandoned rice plantations and is unusually attractive to all species of wild fowl common to the Atlantic coast, and many woodcock and Wilson snipe visit the area. Unfortunately, funds are not available to provide adequate supervision for this reservation or to mark properly its boundaries.

INVESTIGATIONS OF PROPOSED REFUGES

There is urgent need for funds to enable the survey to investigate and determine the suitability of areas that are being proposed for refuge purposes. During the year an engineer was engaged to make a reconnaissance of the Klamath marsh area in Oregon, to ascertain its suitability for refuge uses. It was found practicable from an engineer's standpoint, but the Indians who control the lands have thus far been averse to making any arrangements with the Government for disposing of them for this purpose. A survey was also made of Lower Klamath Lake to ascertain the possibility of flooding a portion of it so as to restore for migratory waterfowl an area long used by these birds. This was found to be impracticable for the reason that the authorized use of the water for irrigation and other purposes would not leave enough to meet the requirements.

LAW ADMINISTRATION

Respect on the part of sportsmen and the public in general for Federal and State laws for the conservation of wild life continues to increase from year to year, and United States district courts and district attorneys have continued their interest in the enforcement of the regulations. There are still many hunters, however, who will violate the law whenever opportunity is afforded.

PROTECTION OF MIGRATORY BIRDS

BETTER LAW ENFORCEMENT NEEDED

Demands for better enforcement of the Federal migratory-bird regulations are insistent and general. Citizens everywhere express their approval of the law but assert that enforcement is notably inadequate. The reason for this criticism becomes evident when it is realized that the appropriation available for enforcing the migratory-bird treaty act regulations allows for the full-time employment of only 24 salaried game protectors throughout the entire country. Each game protector must on the average cover two States, and in his work can have little assistance from the United States deputy game wardens, since funds are not sufficient to permit many of these latter officials—generally voluntary co-operators—to be assigned to this duty. The fact that United States game protectors are known to be few encourages poachers, market shooters, bird snarers, plume hunters, and other violators to ply their illegal trades in contempt of the law, and serves to bring the Federal regulatory work into disrepute among many sportsmen. The establishment of an adequate force of game protectors would have immediate beneficial results in a quickening of public interest in wild-life protection and in strengthening the public support of the migratory-bird treaty act. It is confidently felt that illegal practices in the taking of migratory birds in the United States can be reduced to a practical minimum by a force of not to exceed 100 protectors.

FEDERAL AND STATE COOPERATION

Cooperation between the game protectors of the Bureau of Biological Survey and the State game wardens has continued with gratifying results and with mutual benefit, for Federal protectors in numerous instances discovered and reported infractions of the State game and fish laws. Information and evidence in connection with such offenses have been referred to the State game departments and have enabled them to collect in fines and costs the sum of \$7,860.99. Several United States game protectors have been issued commissions as State game wardens in order to further this cooperation. State wardens also have given Federal officers valuable aid.

Several publications were prepared by the survey and widely distributed to facilitate better cooperation be-

tween Federal and State authorities engaged in conserving our birds and game. One of these was the twenty-eighth annual Directory of Officials and Organizations Concerned with the Protection of Birds and Game, issued as Miscellaneous Publication No. 6 of the department. The annual summary of the game laws of the United States, Mexico, and Canada (Farmers' Bulletin No. 1550) was published, and 390,000 copies were widely distributed; and 110,000 copies of the annual publication containing the fur laws (Farmers' Bulletin No. 1552) were issued. The bureau also issued a pamphlet (S. R. A.—B. S. 68) containing the text of the treaty between the United States and Great Britain for the protection of migratory birds and various Federal laws and regulations for the protection of wild life. The open seasons for game were conveniently set forth in a poster, 16,500 copies of which were issued as soon as possible after adjournment of the State legislatures. This poster was reprinted in numerous sporting and outdoor periodicals, and the information was thus widely disseminated.

A statement compiled by the bureau and issued through the press service showed that about 6,000,000 hunting licenses were issued by the States for the season 1926-27, and that about \$8,000,000 revenue was derived from this source. The larger portion of the funds so received by the States is employed in the protection and propagation of game and fish and in the acquisition and administration of lands for State game refuges.

HEARINGS UNDER THE MIGRATORY-BIRD TREATY ACT

No general public hearings or conferences were held relative to migratory-bird conditions, but a part of the annual meeting of the migratory-bird treaty act advisory board, which was held as usual in the city of Washington during the month of December, was open to the public. The board discussed and approved certain modifications in the regulations affecting open seasons on waterfowl in Illinois and affecting the location of sinkboxes (batteries) in coastal waters. Recommendations relative to the open seasons on gallinules and to the open seasons on mourning doves in South Carolina, Georgia, Florida, Alabama, and Mississippi were also approved. These recommendations were adopted by the Secretary and approved by the President. Upon later representation from the State game authorities of Georgia

and Louisiana the bureau made further recommendations relating to the open seasons on mourning doves in these States and proposed amendments, which were adopted and approved, to bring the Federal regulations into harmony with State laws.

The status of the woodcock has been given much attention not only by the survey but by the advisory board. In New England and in the Maritime Provinces of Canada reports indicate a gratifying increase of these birds, but in the areas west of the Alleghenies to the Mississippi River and in a major portion of the coastal States a serious decrease has been almost generally reported. The latter areas comprise the larger portion of the woodcock's range, and the unfavorable status of the bird in these regions is significant. Accordingly the advisory board favored the recommendation made by the survey that, notwithstanding the situation in New England, the maximum open season on woodcock be reduced from two months to one month. The regulation effecting this change was adopted by the Secretary and approved by the President.

LAW VIOLATIONS AND PENALTIES

During the year migratory bird treaty act cases were handled and disposed of as shown in Table 4. From lack of sufficient evidence, youthfulness of the accused, the imposition of adequate fines in State courts, or other satisfactory reasons, 83 cases reported by United States game protectors were not forwarded for prosecution. Six cases tried before juries resulted in conviction and the imposition of substantial fines. Penalties included jail sentences imposed by Federal judges in 11 cases, and fines ranging from \$1 to \$500 and totaling \$11,213.05. Defendants were placed on probation in 4 cases and paroled for six months in 1 case, and in 4 cases sentence was suspended. Two defendants were pardoned by the President after having served 30 days of a 40-day sentence. Migratory waterfowl illegally possessed or unlawfully killed valued at approximately \$1,000 were seized during the year, and those fit for food were donated to hospitals and other public charitable institutions. Among the violations for which offenders were punished were the following: Selling and shipping waterfowl without Federal permit; trapping ducks; killing ducks in closed season; exceeding the daily bag limit on ducks; shooting waterfowl from power boats; hunting

ducks after sunset and mourning doves prior to half an hour before sunrise; and killing nongame and insectivorous birds for which no open season is provided.

Four persons illegally trapping fur-bearing animals were apprehended by reservation wardens on the upper Mississippi River wild life and fish refuge and prosecuted in State courts, where fines were imposed totaling \$90 with \$125.25 additional costs; two offenders were remanded to jail for 60 days in default of payment. The first cases involving a violation of the act creating this refuge were reported for prosecution and were pending at the end of the year.

Since the passage of section 84 of the United States Criminal Code, designed to protect wild animals and birds and their eggs on Federal refuges, 79 prosecutions have been instituted in Federal courts. New cases submitted to the solicitor during the past year numbered 4; 5 cases were terminated by convictions, with fines totaling \$205; and 1 was dismissed.

PERMITS ISSUED

Scientific collecting and other permits.—

Permits issued during the year to collect migratory birds and their nests and eggs for scientific purposes numbered 200, bringing the total outstanding to 1,665. Thirty-seven scientific possession permits were issued during the year, principally to taxidermists, making the total outstanding 321. Permits issued authorizing the possession and sale of waterfowl for propagating purposes numbered 653, bringing the total number of such permits to 3,750; a number of permits of this description were canceled during the year. Outstanding permits for possessing specimens accidentally killed or found dead now number 469, of which 67 were issued during the year.

Reports on file indicate that 42,155 wild ducks, chiefly mallards, and 4,762 wild geese, mostly Canada geese, were raised in captivity under permit. Included in the total were 670 wood ducks and 169 pintails. These figures constitute a noticeable increase over the reports of the previous year. The propagation of game birds is being encouraged in every practical way, and wide use was made of the bulletin on the subject. There is reason to believe that in some areas where ducks, particularly mallards, have become scarce, restocking might be successfully accomplished through the propagation of birds by sportsmen's organizations and by individuals. Many of the wild fowl raised in captivity have been liberated.

Permits to kill injurious birds.—Three orders authorizing permits for the killing of migratory birds when found injurious were issued by the Secretary under article 7 of the migratory-bird treaty and Regulation 10, as follows:

An order (August 10, 1927) permitting the killing of shrikes by leaders of the cooperative quail investigation, or by any reliable person designated by them, in any manner when found injuring or destroying valuable birds on lands in Thomas and Grady Counties, Ga., and Leon and Jefferson Counties, Fla., on which the quail investigation is being conducted.

An order (August 17, 1927) permitting the killing by shooting of gulls and terns throughout the United States by any person when authorized by a permit issued by the Secretary and countersigned by the Chief of the Bureau of Biological Survey, in such numbers as may be necessary, not exceeding 50 in the aggregate of both kinds, and in sections where such birds have become objectionable about private property or a menace to public health. Permits issued under the

TABLE 4.—Cases of violation of the migratory-bird treaty act handled during the year 1928, disposed of, and still pending

Cases	Number	Cases	Number
Pending from former year.....	403	Disposed of by:	
New cases reported.....	423	Conviction.....	332
Total.....	826	Dismissal.....	57
Disposed of.....	440	Verdict of not guilty.....	10
Pending at end of year.....	386	No bill found.....	3
		Nolle prosequere.....	20
		Abandonment of prosecution.....	15
		Denial by court of permission to file information.....	3
		Total disposed of.....	440

order are valid for one year from the date of issuance.

An order (May 18, 1928) permitting any person, when authorized by a permit issued by the Secretary and countersigned by the chief official in charge of the fish and game laws of the State of Maine or his duly authorized representative, to shoot herring gulls between July 20 and August 20 of any year for which the permit is issued, when necessary to protect the blueberry crops on areas within the State.

INTERSTATE COMMERCE IN WILD BIRDS AND MAMMALS

Administration of the Lacey Act, which regulates interstate commerce in wild birds and mammals, continues to uncover large numbers of violations of State laws relating to traffic in pelts of fur animals. As heretofore most of the evidence of apparent violations has been referred to State game officials for investigation and State prosecution when the shipments proved to have been illegally made. Federal operations are greatly handicapped, and the illegal traffic continues, from the fact that Federal employees are not empowered to seize illegal shipments of skins and furs. Some headway has been made, however, in restricting violations, in that the courts of one State, to prevent violators from profiting by the sale of furs illegally taken or shipped, have ordered the proceeds of such sales to be paid to the State.

When furs have been removed from the jurisdiction of one State and commingled with articles of interstate commerce in another, usually they are not subject to State seizure. A bill has been introduced in the present Congress to confer authority upon employees of the department engaged in enforcing the provisions of the Lacey Act to seize illegal interstate shipments of the dead bodies of wild animals or parts thereof.

In its cooperation the survey has furnished game-protection officials in the various States with evidence of 4,672 shipments that apparently contained illegal skins. During the fiscal year the several States closed 475 cases based on information originally furnished by the survey, in which the aggregate fines assessed amounted to \$17,909.50 and the costs to \$1,237.30, a total of \$19,146.80. Sixty-five beaver skins were seized at the instance of a Federal protector, and sold by the State for \$700. Six cases also were

settled in State court by the imposition of jail sentences ranging from 15 to 90 days each.

No cases involving violations of the Lacey Act were reported for prosecution during the year; but approximately 80 investigations were still pending; 258 investigations involving apparent violations were closed.

IMPORTATIONS OF FOREIGN BIRDS AND MAMMALS

The close of the fiscal year marks the completion of 28 years of supervision by the Biological Survey of the importation of foreign birds and mammals. During this period more than 15,000 permits have been issued for the entry of a corresponding number of shipments, including several million birds and mammals. Approximately 9,000,000 birds have been imported during these years, about 6,000,000 of which have been canaries, 2,000,000 miscellaneous birds, and 750,000 game birds. Complete figures are lacking for the first year in which the law was in operation, and also for 1919 and 1920, immediately after the World War, when importations fell off to a small fraction of the former number. With the exception of five years the total number of birds annually imported has varied from 200,000 to more than 600,000, the half-million mark having been passed only in 1927 and 1928. The figures indicated for 1928 have never before been attained. Canaries have averaged 1,000 a day in 1913, 1914, 1927, and 1928, and in four other years (1907, 1910, 1911, and 1912) they almost reached this mark. Nearly two-thirds of all game birds imported have been Mexican quail. Next to these stand pheasants, formerly a large item in the entries, but State game farms and private enterprises now supply most of the stock for this country, and importations have fallen off considerably. Hungarian partridges reached their highest mark, 36,507, in 1911. Miscellaneous birds have normally varied from 40,000 to 200,000, but in late years have fallen below the maximum. Only in 1922, 1923, and 1927 have they exceeded 100,000, but in 1923 they reached 197,265.

The number of permits issued during the year was 1,211, an increase of 144 over that of the preceding year, and inspection of shipments at ports of entry increased from 337 to 411. Six additional permits were issued at Honolulu, Hawaii, for the entry of 53 miscellaneous birds. The total num-

ber of foreign birds imported was 682,308, of which 8,741 were without permit. The importations under permit consisted of 458,449 canaries, 56,307 parrots, 84,915 quail, and 82,637 representatives of miscellaneous species.

MAMMALS

Permits for the importation of mammals included chiefly foxes, muskrats, and bears, and a number of others largely for exhibition purposes. Comparatively few fur-bearing animals except foxes and muskrats were brought in, and so far as known no injurious species were admitted.

The importation of foxes from Canada again showed a decided decrease from the number imported the previous year, 3,044 as compared with 4,242 in 1927. During the past eight years the records indicate that nearly 35,000 have been brought in from Canada, two-thirds of which were entered in the three years 1924, 1925, and 1926, figures for which were 4,781, 8,424, and 7,809, respectively. The peak, reached in 1925, was followed by a slight decrease in 1926, a falling off of nearly 50 per cent in 1927, and a still further decrease during the past year. The fact that the fox-farming industry is steadily progressing and has now reached a more normal and substantial basis would indicate that the increase of 1924-1926 was due to some special stimulation or that the number of fox farms in the United States has now increased sufficiently to supply a large proportion of the breeding stock.

Besides foxes, muskrats for fur farming and black bears for exhibition purposes have been imported in some numbers. A considerable number of the latter species are brought in each year during summer and early fall. Many inquiries have been received regarding the introduction of the South American coypu, with a view to its establishment as a fur-bearing animal, but as yet no actual importations have been made.

Among the most interesting mammals imported during the year were representatives of the two existing forms of sea elephant (Mirounga), the southern form represented by a specimen from South Georgia, imported by a large circus and placed on exhibition during the spring; and the northern by several Guadalupe sea elephants brought in and exhibited by the San Diego Zoological Society. Thus, for the first time, both of these rare mam-

mals were on exhibition at the same time in the United States. Other interesting mammals included four brown hyenas and several rare monkeys.

BIRDS AND THEIR EGGS

The importation of birds included 84,915 Mexican quail, 12,620 Hungarian partridges, several shipments of pheasants, a few waterfowl, and other miscellaneous game birds. For the first time in several years a number of pheasants were brought in from England, chiefly to introduce new blood. Many of the Hungarian partridges were imported by the State of New York and others were shipped to States in the West, where considerable interest in their introduction has developed.

Permits were issued for the entry of 4,956 eggs of game birds, against 530 in 1927. Shipments this year were chiefly pheasants from England, the largest including 1,500 eggs; eggs of ducks and grouse were also entered from Alberta.

Among the more interesting birds imported were a Somali ostrich (*Struthio molybdophanes*), 2 shoebill storks (*Balaeniceps rex*), 2 mikado pheasants (*Calophasis mikado*), 3 Impeyan pheasants (*Lophophorus impeyanus*), and 26 argus pheasants (*Argusianus argus*), 7 Formosa tree partridges (*Arboricola crudigularis*) and 19 chukar partridges (*Alectoris graeca chukar*); a number of rare pigeons, including 5 Caroline Island pigeons, 3 white-fronted amethyst doves (*Phlogoenas kubaryi*), and 2 doves of the species *Claravis pretiosa*; parrots in considerable variety, including several black cockatoos (*Solenoglossus aterrimus*), 4 hyacinthine macaws (*Anodorhynchus hyacinthus*), 5 rare parakeets (*Psittinus incertus*), and 6 Forster lories (*Trichoglossus forsteri*); 2 queen wydahs (*Diatropura progne*), 3 half-moon wydahs (*Coliostruthus ardens*); and 4 emperor starlings (*Cosmopsarus regius*)—the starlings being imported for the first time in October, 1927.

Mexican quail.—During the season of 1928 the number of quail imported from Mexico was slightly less than in 1927, the total number being 84,915, as compared with 85,141. Of the birds imported this season 28,910 were entered at Brownsville, 33,190 at Laredo, and 22,815 at Eagle Pass, Tex. The system of issuing permits at the border, which proved so successful last year, was continued. The entries, as last year, were made by three import-

ers who held concessions from the Mexican Government. These concessions authorized a larger number of birds than had ever before been imported, and plans were made for shipments on a large scale, but the record of entries shows that the number actually brought in was less than in 1927.

Inspectors of the Bureau of Animal Industry issued all permits for the exact number of birds brought in and examined all shipments at the border before reshipping, but no quail disease was reported. Weekly reports were made on the number of quail entered and details as to shipments. These quail were distributed to about one-third of the States, as follows: Kentucky, 12,155; Alabama, 12,035; North Carolina, 8,719; Maryland, 7,505; Oklahoma, 6,624; Georgia, 5,560; Virginia, 5,496; Kansas, 5,044; Texas, 4,267; Florida, 3,716; Pennsylvania, 3,607; New York, 3,210; Missouri, 1,832; New Jersey, 1,412; South Carolina, 566; and West Virginia, 536. Several small shipments to other States included about 2,585 birds.

New regulations (S. R. A.—B. S. 69), which, among other provisions, modified the size of crates for shipping quail, went into effect on November 21, 1927. The main object in reducing the size of the crates was to make them lighter and thus not only cut down express charges but render practicable their return and re-use.

After the close of the season a movement was started among southern importers to change the season so that quail could be obtained earlier in winter. This, however, does not meet with approval in some of the Northern States, and moreover, would be within open seasons for quail shooting, which do not close in five of the Southern States until after February 1. The distribution of large numbers of high-priced quail before the season closes would seem a doubtful and expensive experiment, and one well-nigh useless unless the birds could be placed on preserves or areas closed to all hunting.

CAGE BIRDS

About one-third of all the known species of parrots have been brought in at various times for purposes of exhibition, and, like canaries, have increased considerably since the World War. Very few parrots breed in captivity in the United States, but some live for a number of years. The number imported annually varies from about 35,000 to 60,000. Of these the largest number are shell parakeets, or bud-

gerigars, from Australia; and several kinds of Amazons, including Cuban parrots Panama parrots, and double yellowheads from Mexico. Considerable numbers of cockatoos also were brought from Australia, and some of the rarer parrots and parakeets from the West Indies and South America. One interesting genus of African parakeet (*Agapornis*), represented by 10 species, has recently become popular, and at least 8 of the species have been available for aviaries in this country.

The shipment of cage birds from Mexico continues but in reduced numbers. The Mexican Government now requires export permits for cardinals, mocking birds, and certain other species, and before importation permits are issued it is necessary for the importer to obtain not only authority for export from Mexico but authority for possession from the State to which they are consigned. Notwithstanding the restriction of State laws on possession and traffic, applications still continue to be made for the entry of cardinals, mocking birds, and nonpareils.

PROTECTION OF WILD LIFE IN ALASKA

Alaska possesses many interesting and highly valuable forms of wild life that need more protection than is now afforded them through the limited resources available to the Alaska Game Commission. With fairly large numbers of such noted big-game animals as the mountain sheep, the moose, the caribou, the mountain goat, the deer, and the grizzly and Alaska brown bears, and with foxes, beavers, minks, muskrats, and lynxes present in considerable numbers, there exists a real opportunity to put into effect a wild-life administration program that not only will insure a continuance of game and fur animals in present numbers, but should operate to increase the stocks of many of these and of other species, including the marten, which, without better protection, must rapidly go down hill. Forward-looking Alaskans are behind the work of the Alaska Game Commission. Demands are being made for more strict law enforcement than can be given by the commission through its force of seven full-time wardens. Each of these wardens is expected to handle an area of over 70,000 square miles, as compared with only 100 square miles covered by wardens in the better organized States.

Violation of the Alaska game law and regulations is only too frequent because of the small enforcement per-

sonnel now available. During the year the operating expenses of the Alaska Game Commission were more than \$67,000. From the sale of licenses and from fines and forfeitures for the same period there was derived \$66,000. It is a certainty that the Alaska Game Commission can not fully redeem its responsibility or with success carry out its game and fur conservation and protection program without more funds with which to increase its force of wardens and to provide more adequate transportation facilities for them, particularly boats of a kind that can be kept continuously in service under adverse weather and sea conditions. At present the boats of the commission have to be laid up part of the year because of insufficient operating funds.

Most of the governmental agencies in Alaska do not have enough field work in the winter season and their boats are laid up. Not so, however, with the Alaska Game Commission. The trapping seasons are on from November to March, and it is essential that the wardens be in the field at a time when without suitable boats they are confronted by grave danger in the adverse weather conditions that they are certain to encounter.

The regulations adopted by the Secretary under the Alaska game law of January 13, 1925, already have shown their effectiveness in the conservation of the wild-life resources of the Territory. A popular presentation of the improvement in wild-life conditions there was the basis of an article prepared in the bureau and published in the 1927 Yearbook. Only such changes in the original regulations have been adopted from year to year as investigations have shown to be necessary. The regulations this year were published in Circulars Nos. 4 and 5 of the Alaska Game Commission. Enforce-

ment of the new law and the regulations of the Secretary are under the immediate jurisdiction of the five commissioners authorized by the act, one of whom, the administrative officer, is the chief representative of the Bureau of Biological Survey resident in the Territory.

The amendments adopted this year affect moose, caribou, mountain sheep, and bears. The relative scarcity of moose on the small section of the Alaska Peninsula inhabited by them made it appear advisable to close the season in that region until such time as this animal shows a satisfactory increase. Large brown and grizzly bears also were afforded additional protection on the Kenai and Alaska Peninsulas and in the Kodiak-Afognak Islands group by a reduction in the bag limit from 3 to 2 a season. The limit allowed nonresidents on caribou and mountain sheep was reduced from 3 to 2 each a season. Other amendments affecting big game relate to the handling of the meat of such animals in cooked form in certain portions of the Territory under permit of the Alaska Game Commission.

Last year the regulations provided short open seasons on beaver in certain regions and prescribed a system of tagging the skins of these animals, whether taken within or coming from outside the Territory. This year the season was again closed throughout the Territory, and it is contemplated that the tagging system will be of great assistance in protecting beavers much more effectively. Beaver poaching was formerly a common practice in many sections of Alaska, but owing to the limited force at the disposal of the commission, strict enforcement of the law and regulations proved impossible. Under the tagging system now in effect untaged skins will be subject to seizure.

DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF CHEMISTRY AND SOILS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY AND SOILS,
Washington, D. C., September 1, 1928.

SIR: I have the honor to submit herewith the report of the work of the Bureau of Chemistry and Soils for the fiscal year ended June 30, 1928.

Respectfully,

HENRY G. KNIGHT,
Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

INTRODUCTION

With the close of the fiscal year 1928 the Bureau of Chemistry and Soils passed its first milestone. The new organization came into existence on July 1, 1927, for the purpose of correlating all of the research work of the Bureau of Chemistry and the Bureau of Soils. The Bureau of Soils included in its field of research not only all investigations relating to soils but also those concerned with fertilizers and the work formerly assigned to the Fixed Nitrogen Research Laboratory. In addition to the work of these two organizations, the new bureau took over from the Bureau of Plant Industry the Division of Soil Fertility and the Division of Soil Bacteriology. Having divorced the regulatory from the research work of the former Bureau of Chemistry, the new bureau became primarily a research and fact-finding institution covering a wide range of subject matter pertaining to land utilization, soil fertility, fertilizer-resource development, and the utilization of agricultural products of various kinds. Within the same organization are now to be found the soil survey, which is laying the foundation for the mapping and study of the Nation's soil resources, soil-fertility studies having for their purpose the better utiliza-

tion of the soil, and, finally, the application of chemical and engineering technology to a study of fertilizer resources and the more economical and diversified utilization of the products of the soil.

The research work now in progress includes investigations on soil chemistry, soil physics, soil erosion, soil microbiology, soil fertility, nitrogen fixation, potash and phosphate resources, crop chemistry, fruit and vegetable chemistry, fermentation methods for the production of organic acids, utilization of farm and industrial wastes, food microbiology, dust explosions and farm fires, and on improved technic for the production of sirups, sugars, vegetable oils, proteins, insecticides, fungicides, tanning materials, and a variety of other products.

For the purpose of administration three large units are recognized within the bureau: (1) Chemical and Technological Research, (2) Soil Investigations, and (3) Fertilizer Resources and Fixed Nitrogen Investigations. Each of the three units is in charge of a chief scientist, who not only directs the work of his unit but also serves as a member of an informal coordinating board within the bureau. By virtue of its broadened field of activities and the coordinated effort within the bureau the new organization is given the opportunity to attack problems along

much broader lines than has been possible in the past under the separate organizations which hitherto existed. It is believed that under the new arrangement it will be possible to give better service to the public for the same amount of money expended, and at the same time to expend more effort along broad lines of fundamental research. In the main the appropriations are made to the bureau for the purpose of attacking specific problems, the solution of which are of interest to the business of agriculture and have, therefore, a utilitarian objective. However, direct attack upon some of these problems in the absence of essential fundamental knowledge is wasteful of funds and energy. The search for this fundamental knowledge frequently leads the scientist into the realms of pure science, where the foundation is laid for the logical attack and final solution of the problem under consideration. Such a method of attack requires careful, thoughtful planning, the development of skilled technic, an intelligent and discriminating analysis of results, and ability of a high order to make the necessary practical applications.

Many of the research problems pertaining to the work of the Bureau of Chemistry and Soils are of such wide scope and national interest that their final solution must of necessity have a wide application. Certain problems of more or less regional interest must also receive consideration, but in most instances these can best be attacked by securing the active cooperation of the States or other local agencies.

The interest of the farmer should not terminate with production of his crops, but he should be in position to follow his products through to the ultimate consumer if he is to be in position to adjust his productions to the demands of the market. To this end the bureau should not only function as a research agency to increase efficient unit production, but should also be in position to follow the products of the farm through the industrial processes that make use of raw agricultural products in the manufacture of articles of commerce. The research activities of the bureau along this line should result in the more economical utilization of farm products and the production of more uniform final products, thus benefiting both the farmer and the ultimate consumer. The widening of markets for farm products through the development of new channels for their industrial utilization is an important function.

Recognition of the close interrelationship between agriculture and the industries that utilize agricultural products has led to the development of plans which will give these industries an opportunity for investigation and analysis of their individual problems under the leadership of the bureau. Under these plans research fellowships are established within the bureau, which will insure careful and conscientious research upon the problems chosen. Such contacts must result in mutual benefit to all concerned.

Results obtained in fertilizer and fixed-nitrogen investigations are being applied by industry as rapidly as conditions appear to warrant, thus reflecting direct benefit to agriculture in the form of cheaper and more satisfactory sources of plant-food materials. Advancement in this field depends largely upon the development of fundamental research and the application of the laws and principles thus discovered or verified to the technic of manufacture. Such researches are primarily functions of the Federal Government, since they are directed to the development of a more efficient national agricultural program.

In the broader aspect, the Bureau of Chemistry and Soils is a research and fact-finding governmental agency, having as its aim the development of an intelligent land-utilization policy and an efficient crop-production and utilization program.

CHEMICAL AND TECHNOLOGICAL RESEARCH

C. A. BROWNE, *Chief*

CARBOHYDRATE INVESTIGATIONS

CANE SIRUP

Investigations on the more economical utilization of low-purity cane juice were continued. The purpose of this study is to determine whether this juice can be used for sirup rather than for sugar manufacture. The results so far obtained indicate that low-purity juice alone does not yield an acceptable direct-consumption table sirup. It is possible, however, to obtain from such juice a satisfactory blending sirup, which, when mixed with glucose or a sugar sirup, produces a high-quality mixed sirup of its type. If a factory is producing only table sirup, a high extraction of the cane may be employed without injuring materially the quality of the finished product, provided the juice is

divided into two portions, each treated separately. The first portion would consist of the low-extraction juice from the crusher and first mill and may be clarified and concentrated in the usual manner for producing sirup. The second portion, consisting of the lower-purity juice, may be clarified by a special process which has been developed, and may then be concentrated, either separately or after mixing with the first portion. The two portions should preferably be mixed in the same volume ratio, that they are extracted from the cane.

The sirup from the low-purity juices may also be utilized in the production of "cane cream," a new product which has recently been developed by this division. The manufacture of "cane cream" has been undertaken on a semicommercial scale, and the results indicate that the cost of manufacturing a high-quality product is moderate. The fabrication of the product is a part of a general plan for the production of specialties which are believed to be of great economic importance for the Louisiana sugar and sirup industry.

At the urgent request of a large Louisiana sirup producer an investigation relating to the cause and remedy of "swells" in canned sirup was undertaken. A peculiar condition exists in that in certain localities the un sulphured type of sirup causes considerable trouble by producing "swells" during storage. This results in a large loss of canned stock. The trouble is caused not by fermentation but by a slow chemical decomposition, the exact nature of which has not yet been determined. A number of samples of Louisiana cane sirup have been examined, but the usual chemical analyses have given no conclusive indication as to the nature of the chemical changes which occur. The theory has been advanced that the reaction between amino acids and reducing sugars, normal constituents of the juice, is responsible. This possibility is being studied in detail with a view to ascertaining the cause and devising a remedy.

CANE SUGAR

In recent years the filterability of raw sugars has been receiving considerable attention because of the higher cost of refining a poor-filtering sugar. This has in turn affected the raw-sugar producer, since a poor-filtering sugar is in less demand under present market conditions. An investigation

was undertaken for the purpose of determining the primary cause of this variation in raw sugars, especial attention being given to the colloid content and ash constituents. Different features of factory operation were studied in relation to grades of sugar produced in order to determine to what extent factory control affects the filterability of the resulting sugars.

Observations were made at several factories operating by somewhat varying methods and using cane of different varieties grown under distinctly different climatic conditions. The colloid content of the various sugar end products was determined by means of the dye test and ultrafiltration. The separated colloids were subjected to various types of examination for the purpose of discovering further relations between colloids and filterability. Certain sugars were washed to approximately 99.5 per cent purity and analyzed and filtered in order to ascertain to what extent nonsugar substances embedded in the crystals affect filterability.

The quality of the juice entering the process was found to be of especial significance. The quality may be affected by the conditions under which the cane is harvested, by its maturity, or by the climatic conditions under which it is grown. Variety is probably another factor of importance. The investigation is being continued for the purpose of devising means of control.

SUGAR DETERIORATION

Considerable progress was made in the study of means for preventing the deterioration of raw cane sugar during storage. This work is being conducted along two lines, one of which relates to the hygroscopicity of sugars and sugar products and the means of controlling it, and the other to a study of the efficiency of fumigants in destroying microbiological activity in raw sugar. The problem of sugar storage is a very important one, inasmuch as every year a very large loss of sugar occurs. The best conditions for storage and the possibility of the use of fumigants for destroying microorganisms have not yet been satisfactorily determined.

BEET SUGAR

In continuing the investigation relating to beet-sugar manufacture, a study of the possibility of an automatic control of the carbonation and sulphitation processes in the clarification of beet juices was successfully made. An accurate control of these

processes, particularly the second carbonation and sulphitation of the thin juice, is very desirable. At these stages a delicate adjustment in alkalinity must be made in order to obtain the maximum elimination of impurities, including lime salts, which, if present in excessive quantity, cause considerable trouble by scaling the heating surfaces of the evaporators and vacuum pans as well as preventing the maximum recovery of sugar from the juices.

An automatic pH control of the second carbonation station in beet-sugar manufacture was installed experimentally during the past season to determine the practicability of this method of obtaining a closer control and also a permanent record of the pH of the juice over a 24-hour period. Tungsten electrodes were used with good results in carbonated juice and also functioned satisfactorily in sulphured thin juice.

IMPURITIES PRODUCING COLOR

Further progress has been made in determining the character of substances present in various grades of sugar which cause the production of objectionable color in commercial products made therefrom. Several inorganic compounds produce this effect, but the substances which are most objectionable are organic and colloidal in nature. All of these substances are present in very small proportions, but have quite pronounced effects in lowering the caramelization point of sugar and producing dark color, especially at the higher temperatures to which sugar is subjected in preparing certain food products. Under certain conditions decolorizing carbons will overcome the difficulty, but a satisfactory process for commercial application has not yet been found.

HONEY

A revision of Bureau of Chemistry Bulletin 110, Chemical Analysis and Composition of American Honeys, has been undertaken. For this revision new analytical data are desired, since some of the official methods have been changed during recent years. The analysis of numerous typical honeys was therefore undertaken, and the work is partially completed.

STARCH

At the urgent demand of a number of sweet-potato producers' associations, an investigation has been started pertaining to the economical utilization of excess and cull sweet pota-

atoes, of which there is available an enormous quantity throughout the Southern States. Various means of utilizing these waste potatoes have been suggested in the past, but no satisfactory method has yet been found. Owing to the relatively high starch content of sweet potatoes, there is a possibility that the waste portion of this crop can be utilized in the production of starch. In order to investigate this possibility a starch plant having a daily capacity of approximately 100 pounds of dry starch was erected, and trial runs were made. Starch of good quality was obtained, but further investigation must be made to determine such factors as the cost of commercial production, yield, and most economical size of factory. Study of the properties of the starch must also be undertaken in order to determine its commercial uses and value.

MISCELLANEOUS INVESTIGATIONS

The efficiency of filtration and other clarification processes is frequently judged by the degree of turbidity of the clarified juice or other liquor, but the operator has been handicapped by having no equipment available for measuring turbidity accurately in numerical terms. An instrument was, therefore, developed for this purpose. It is rugged in construction and is capable of measuring turbidity in numerical values and in detecting differences invisible to the naked eye.

In view of the fact that considerable discrepancy exists between the results of various investigators on the 100° point of the Ventzke sugar scale for saccharimeters, a redetermination of this important constant was made. This work was done in cooperation with the New York sugar trade laboratory. The results from the two laboratories agree with the value found by the Bureau of Standards rather than with the values of European investigators.

DUST EXPLOSIONS

Studies were continued to determine the causes of dust explosions in various types of industrial plants and to develop methods for their control and prevention. The work already done indicates very definitely that practically all types of combustible dusts, when mixed with air in proper proportions, are explosive and that at least 28,000 industrial plants in the United States are subject to this hazard. These plants employ approxi-

mately 1,324,000 people and manufacture products having an annual value in excess of \$10,000,000,000. The Bureau of Chemistry and Soils is the only governmental agency conducting research studies relating to industrial plant dust-explosion prevention. The bureau is recognized as a leader in this undertaking in the United States and is frequently called upon for assistance by foreign countries.

ORGANIZATION OF WORK

Research on the subject is organized along two definite lines: (1) Engineering investigations relating to the determination of the causes of explosions and to the design and development of mechanical equipment and appliances for their control and prevention; (2) chemical investigations in connection with the determination of the relative degree of explosibility of industrial plant dusts. This work includes research to determine the factors contributing to the explosibility of the dusts, ignition temperature, rate of flame propagation, pressures developed, and similar important factors.

INERT GAS

During the year attention was given to the development of methods for the use of inert gases for the prevention of dust explosions and fires. A large number of demonstrations was given at the Arlington experimental plant, and the results of the work have been published in Technical Bulletin No. 74, entitled "The Value of Inert Gas as a Preventive of Dust Explosions in Grinding Equipment." The engineers working on this problem have cooperated with a large number of industrial companies in arranging for the installation of equipment for the utilization of boiler-flue gas. As a result of this work one of the largest feed-grinding companies in the country has planned an installation of this character sufficiently large to provide inert gas for all the grinding equipment, conveyors, and elevators where the dust-explosion hazard is recognized. This apparatus has been designed to handle approximately 150,000 cubic feet of boiler-flue gas per hour.

Special attention was given to solving the problem of sulphur-fume elimination in connection with the use of flue gases in installations of this character, and tests to develop a satisfactory type of scrubber for this purpose are under way.

DUST EXPLOSIONS HAZARDS COMMITTEE

In its work on dust-explosion hazards the bureau enjoys close cooperation with industrial companies, State commissions, insurance organizations, fire-prevention associations, and practically all agencies interested in explosion and fire prevention. Among the important contacts is that with the National Fire Protection Association through the work of the dust explosion hazards committee. The engineer in charge of the dust explosion work in the bureau is chairman of this committee, which is composed of representatives of industries and agencies directly interested. The dust explosion hazards committee has prepared regulations for explosion control for the following lines of industry: Flour and feed mills, sugar and coco-pulverizing systems, terminal grain elevators, pulverized fuel installations, and starch factories. These regulations have been approved by the American engineering standards committee and are used as a basis by insurance underwriters, State and municipal officials, and safety organizations.

A digest of State health and labor laws, and also safety codes, was made during this year with a view to preparing an adequate dust-explosion-prevention code which would be of service to State commissions in connection with their factory-inspection work. Special attention was given to the results of a survey of dust explosions in foreign countries and the methods that had been introduced for their control.

The more important dust explosions investigated during the past year include pyroxylin lacquer dust, sugar dust, wood dust, cork dust, feed dust, and fertilizer dust. These explosions involved a property loss of over \$4,000,000, with 67 persons killed or injured.

CHEMICAL INVESTIGATIONS

Progress was made in the chemical laboratory investigations in determining the oxygen dilution necessary to prevent dust explosions. Values for oxygen dilution were determined for ground cork, ground pyrethrum flowers, ground oat hulls, and powdered aluminum. It was found that with aluminum the concentration of the dust cloud affected the oxygen dilution required, while none of the other dusts tested exhibited this phenomenon in such a pronounced manner. Different

types of ground pyrethrum flowers exhibited a variation in explosibility. Some samples gave very little pressure, whereas others produced pressures comparable with the more explosive dusts. Microscopical examinations showed that explosibility is largely dependent on the pollen content of the flowers. Ground cork produced the highest pressure with normal air, but the pressure was reduced very rapidly with the introduction of carbon dioxide. Ground oat hulls did not produce as high pressure with normal air as did cork, but the same oxygen dilution did not have the same quenching effect on the oat hulls as it did with the cork. Lower limits of concentration for explosion of ground cork, pyrethrum flowers, and oat hulls were established, and the flame-propagation temperatures of several types of dusts were determined.

During the year the bureau was called upon to conduct tests and to determine relative flammability, ignition temperatures, particle size, moisture, and ash for alfalfa dust, corn dust, ground antimony, cocoa dust, carbon black, fertilizer dust, wood dust, pecan-shell dust, wood flour, and peat. Special attention was given to the development of methods for determining the explosive density of dust clouds, and studies were made of various types of equipment designed for this purpose.

FARM FIRES

According to a conservative estimate, farm fires annually take a toll of 3,500 lives and destroy \$150,000,000 worth of property.

The bureau has undertaken a study of the causes of farm fires, with a view to devising new and improving existing methods and equipment for fire prevention and protection. Research is planned along engineering, chemical, bacteriological, statistical, and educational lines.

The principal known causes of farm fires, in order of their importance, are: Spontaneous ignition of hay, grain, feeds, and other agricultural products; lightning; defective chimneys and heating apparatus; sparks on combustible roofs; careless use of matches in smoking; careless handling and storage of gasoline and kerosene; and faulty wiring and improper use of electrical appliances.

SPONTANEOUS IGNITION OF AGRICULTURAL PRODUCTS

One of the first problems to be studied will be that of the spontaneous

ignition of hay and other agricultural products. It is generally known that improperly cured or damp hay, grain, and feed, when stored in large piles, are subject to spontaneous heating. If conditions are favorable, this heating will progress until ignition occurs. This phenomenon is believed to be due to both microorganic and chemical action. Even though the heating should abate before the ignition temperature is reached, the resulting deterioration of the products represents a staggering loss.

Studies by the engineers and bacteriologists of the bureau are being continued to find a means to store hay so as to prevent its spontaneous ignition. Attempts at isolation in pure cultures of thermophilic organisms capable of decomposing cellulose with the liberation of inflammable gas have been made with moderate success.

It is planned to conduct several large experiments on the spontaneous ignition of agricultural products during the harvest season of 1929 and to correlate the bacteriological, chemical, and engineering phases of the problem. Special studies will be made of the effect of modern haying machinery and methods upon the spontaneous heating and ignition of hay.

VERMONT FLOOD INVESTIGATIONS

The spontaneous heating of wet hay stored in barns following the Vermont flood of 1927 offered an unusual opportunity to study a new phase of this phenomenon. An investigation of conditions was conducted by an engineer and a bacteriologist of the bureau. During the flood the high waters of the Winooski, Missisquoi, and Lamoille Rivers entered many barns and rose to a height of 17 feet in the stored hay. When the waters receded the spontaneous heating of the wet hay was so severe that the barns and their contents were endangered, and in order to save the barns from fire the steaming hay was removed. A barn near Middlesex, Vt., housing 50 tons of hay and standing in several feet of water, burned three days after the flood receded. On a second visit made to the affected sections five months after the flood it was found that the stored hay in some barns was still heating, and in one instance it had become so hot during the winter that it was removed from the barn in January. Very little of the wet hay had dried during the winter months, and most of it was a total loss, as it could not be fed to

animals and little could be used for bedding.

FLORIDA PEAT-SOIL FIRES

The bureau was also called upon for assistance in studying fires in the peat soils in the Everglades of Florida during the past winter and spring, and specialists made a preliminary survey of the situation. It was found that approximately 1,250,000 acres of peat soil had been burned over, the burning ranging from mere surface burning in some sections to a depth of several feet in others. It has been estimated that the monetary loss as a result of soil damage is approximately \$60,000,000. While news reports assigned spontaneous ignition as a cause of these fires, the survey did not afford confirmatory evidence. Whether or not peat soil or peat in storage is capable of spontaneous heating and ignition, however, is a question that can be settled only by actual experiment. It appears that the majority of the peat fires were caused indirectly by drought and overdrainage and directly by "clearing off" operations and by careless hunters, trappers, and smokers.

FARM FIRE-PROTECTION COMMITTEE

The bureau has leadership in the work of the farm fire-protection committee of the National Fire Protection Association, the chairman and the secretary of this committee both being members of this bureau. Three meetings were held during the year—one in Boston, one in Chicago, and one in Atlantic City. In addition to the Bureaus of Chemistry and Soils, Agricultural Economics, and Public Roads, of the Department of Agriculture, and the Bureau of Standards, of the Department of Commerce, the committee membership represents 14 nationally known organizations. The Bureau of Chemistry and Soils is also cooperating with the National Fire Waste Council, the American Society of Agricultural Engineers, and others in the study of the farm fire problem.

OTHER PROPOSED RESEARCH

Proposed research work also calls for the devising of a practicable way of storing and handling gasoline and kerosene on the farm; the development of a simple, inexpensive, effective first-aid extinguisher for farm use; and studies on lightning protection, construction and location of buildings,

farmstead wiring for electricity, and rural fire-fighting apparatus.

VISUAL EDUCATION, EXHIBITS, AND PUBLIC INFORMATION

The work of the bureau on visual education, exhibits, and public information is being conducted under the direction of this division. During the year considerable time was devoted to the preparation and installation of the exhibit of the Department of Agriculture at the New York Chemical Exposition. This exhibit attracted considerable attention from the industries.

Special exhibits were prepared and installed at the annual meeting of the Association of Official Agricultural Chemists in Washington and at the industrial exposition held under the auspices of the Washington Chamber of Commerce.

COLOR INVESTIGATIONS

INDUSTRIAL WASTES

Research on the high-boiling coal-tar acids has been concluded, and samples of the materials sought were sent to a commercial firm for testing in the making of resins. The report was quite satisfactory and was accompanied by a request for larger samples for further tests. These samples are now being prepared.

In an effort to make a suitable resin from furfural and other well-known resin-forming materials a number of articles were molded from a resin made by the furfural-phenol-hydrochloric acid combination. One article, made by combining furfural with the phenols obtained by the destructive distillation of corncobs, indicates some of the possibilities of utilizing farm wastes.

DYE INTERMEDIATES

A study of the production of 2-aminoanthraquinone, an important vat dye intermediate, has been satisfactorily concluded. This investigation was undertaken at the suggestion of the industries because of the need of a cheaper and better method of production. The problem was solved by preparing pure chloranthraquinone from chlorobenzene by the Friedel-Crafts reaction, with a net yield of over 90 per cent. The halide was then treated either with 40 per cent aqueous ammonia or with a nitrobenzene ammonia solution to obtain the beta-aminoanthraquinone. A method of purification was perfected to give a product of 98 to 99 per cent purity. It is expected

that the technic developed in this process will be of great value to the American dye industry because (1) the method is shorter and cheaper than the present operating procedure utilizing anthraquinone-B-sulphonic acid, (2) high yields are obtained in each step of the processes, (3) a very pure product is obtained, and (4) no organic solvents or costly recrystallizations are necessary.

The production of alizarin from O-dichlorobenzene and phthalic anhydride by means of the Friedel-Crafts synthesis and the subsequent fusion of the dichloroanthraquinone with caustic soda has been almost completed. Data have been obtained from which it is believed a commercial process may be developed to prepare alizarin from O-dichlorobenzene, a waste product from the manufacture of chlorobenzene, thus removing our dependence on foreign sources for this material and at the same time utilizing an industrial waste.

An exhaustive study of the nature and application of the Friedel-Crafts synthesis work on the preparation of naphthanthraquinone with a view to the further utilization of phthalic anhydride in the manufacture of vat dyes is progressing. It is planned to continue this phase of the investigation until the process is susceptible of commercial exploitation. Further work relates to the condensation of phthalic anhydride with diphenyl, dibenzyl, starch, glucose, and alcohol.

FARM-WASTE INVESTIGATIONS

AGRICULTURAL WASTES

Experiments to find means to utilize peanut shells have resulted in the production of a good white pulp that meets the published specifications for rayon pulp. Two commercial firms are interested in this product and samples will be tested.

The possibility of making insulating briquettes from corncobs was investigated during the year, and two plans were evolved which give promise of satisfactory results. One method is to add 10 per cent of asphaltum binder to the corncobs and then compress the whole mass in a hot mold. The other requires softening of the cellulose material in the corncobs with a very small quantity of dilute caustic and then compressing the mass at a high temperature. It is believed that corncobs may be used in briquettes as a substitute for cork and may be espe-

cially valuable in small refrigerating units.

An investigation of the production of gluconic acid from glucose by means of the fermenting action of molds has been completed. Optimum conditions have been determined on a laboratory scale, and these results have been carried to a semiplant scale and applied there in an apparatus which may be used as a model for industrial development of this process. A number of commercial firms are co-operating with the bureau in its effort to find a use for this acid.

LIGNIN INVESTIGATIONS

Various sources of lignin have been studied during the year. It has been found that sulphonated lignin can be combined with aromatic bases to make dyes. Lignin has also been destructively distilled, and the products of distillation include acetone, methanol, acetic acid, guaiacol, and eugenol. Further development of this phase of the work may be of commercial interest. The metabolism of lignin in the animal body has been studied and also its rôle in the production of humus in the soil. Certain valuable resins have also been made by the combination of lignin with aromatic amines.

CROP CHEMISTRY LABORATORY

The crop chemistry laboratory was created for the purpose of making a scientific study of the factors, both natural and artificial, which affect the quality of our crops, with the idea that when the interrelation of these factors is more fully understood it will be possible to modify existing agricultural practice so as to produce improvements in the quality of our food supply. Some of the specific problems being studied include improvement in the quality of wheat, especially with reference to the protein content; increasing the content in crops of minor chemical elements such as iron, manganese, and iodine, which may be of great significance in nutrition; and the effect of soil acidity on the yield of crops and crop plants.

The work to improve the quality of wheat has been continued. To obtain further data on the effect of spacing the rows and of applying varying amounts of sodium nitrate at time of heading, 2 acres of wheat were planted at the Arlington Experimental Farm, Arlington, Va. Previous experiments with small plots showed that spacing rows 2 feet apart did not materially diminish the yield and that sodium

nitrate applied at heading time increased the protein content of the grain by as much as 50 per cent. In order to ascertain whether these results could be expected over larger areas, 5 acres were planted to wheat on a farm near Wheaton, Md., half having the rows spaced 2 feet apart instead of the customary 8 inches.

Crop-chemistry problems under consideration include the effect of soil reaction on the yield and composition of green vegetables, with special reference to the iron content, an investigation of the absorption of phosphorus and potassium by seedling plants, and an analytical study of the manganese content of a large number of widely used cereals.

FOOD RESEARCH INVESTIGATIONS

PHYTOCHEMICAL INVESTIGATIONS

The phytochemical research has for its aims the isolation of definite organic compounds and their characterization, the determination of their constitution, the study of their formation and progressive changes in the living plant, and, if possible, the means for their synthetic production.

During the year problems on the biochemistry of the apple were transferred from the Bureau of Plant Industry, and a varietal comparison of apples with respect to waxy coating and cutin was undertaken with the object of determining if the quantity of waxlike constituents on different varieties is definitely associated with degree of wilting or related in some way to the susceptibility to storage scald. A study of the apple surface compounds is also of importance because of a possible bearing on work dealing with the removal of arsenical spray residues from apples, which is being undertaken in the Northwest. Samples of 12 commercially important varieties grown at Arlington farm, representing three stages of growth, and a final storage sample for a number of varieties will be examined.

A chemical study of the waxlike constituents of the apple surface is also under way, the work being confined to a study of malol, one of the chief constituents of so-called apple wax, and a comparison of it with similar compounds from other sources is being made. Considerable quantities of chemically pure substances have been isolated, malol from apples, urson from bearberry leaves, prunol from wild-cherry leaves, oleanol from olive leaves, caryophyllin from clove buds,

and unidentified materials from grape pomace and dogwood bracts. Malol was subjected to ultra-violet light with the thought that it might possibly exhibit antirachitic activity, but no such change was noted.

FROTH FERMENTATION OF MOLASSES

One of the problems of the sugar house is the spontaneous decomposition of molasses, a condition known as froth fermentation. An extensive research is under way on the acids, nonsugars, and unfermentable sugars of molasses to determine, if possible, the cause of such fermentation. Considerable progress has been made in the investigation. The chief acid of natural origin in molasses was found to be aconitic acid, a constituent of sugar-cane juice. It is accompanied by very small amounts of malic and citric acids. The volatile acids of molasses were identified as formic and acetic acids. The study of the unstable acids of molasses, such as the more or less hypothetical "glucic" acid, is not yet complete.

CANNED SIRUP AND MOLASSES

Work is in progress to determine the biological and chemical causes for the production of gas in canned sirup and molasses. All the samples examined contained living spore-forming aerobic bacteria, and other samples contained living sugar-tolerant yeasts. It is known that yeasts can develop in mixtures of carbohydrates having a density of 61 per cent total solids. This study is as yet incomplete, but its successful conclusion should lead to a reduction of swells in canned sirup and molasses.

SPOILAGE OF CANNED VEGETABLES

Data resulting from an investigation of canned vegetables demonstrate the significance of the thermophilic spoilage organisms of the "flat sour," "sulphur," and "hard-swell" types as factors producing spoilage of canned goods. Studies made at pea and corn canneries showed that when a focus of heavy infection of the spoilage thermophiles existed within a factory, a large percentage of the canned product was also contaminated and liable to thermophilic spoilage. In determining the sources of the organisms it was noted that the "sulphur" and "hard-swell" types were present in fertilized soils and natural fertilizers and that the "flat-sour" type was

demonstrable only in the sugar used for making the sirup. Study of a large number of sugar samples showed that spoilage thermophiles entered the refineries in the raw sugar, increased in number in the refining processes, and were only partially eliminated from the granulated market sugars. Granulated cane sugars contained spoilage thermophiles more often than did the granulated beet sugars. Putrefactive anaerobes were found in a high percentage of the samples.

FUNGI COLLECTION

A collection of fungi and sugar-tolerant microorganisms of economic importance to food-deterioration studies obtained from the Japanese shoyu industry and industrial fermentation processes has been developed. This collection was selected from hundreds of cultures isolated over a long period of years. The maintenance of such a collection is of value to chemical, biological, and technical studies in this department and other institutions.

FIG INVESTIGATION

During the last few years diseases and insect pests have become more and more serious in the production of figs in California, so that a large amount of the 1926 crop was condemned by food-control officials. In an attempt to understand more fully the various details of the situation, and to seek methods for eliminating the loss which had become so great as to threaten the very industry itself, a study was made during the year in co-operation with the Bureau of Entomology, the Food, Drug, and Insecticide Administration, and California State officials. Orchard and factory conditions were investigated to gain a comprehensive understanding of the various phases of the problem, both theoretical and practical. In this study it was found that the problem is a most complex one, involving closely interlocking questions of entomology, plant disease, horticulture, and practices as to harvesting, curing, and handling in the packing houses. It has been variously estimated that the loss from the combined causes in 1927 was from 25 per cent to 40 per cent of the crop.

Growers and packers were instructed in the characteristics of the diseases and insect infestation and in methods of testing and sorting to produce a more acceptable product.

FRUIT AND VEGETABLE CHEMISTRY LABORATORY

The fruit and vegetable chemistry laboratory, at Los Angeles, Calif., is engaged in the development of new and improved by-products from cull or surplus fruits and vegetables and is studying the composition of fruits and vegetables with reference to their maturity and the influence of chemical and other agents on their composition and ripening, as well as the inheritance of composition through vegetative propagation. It is actively interested in investigations of dehydration and sundrying of fruits and vegetables, with special reference to the sulphuring of apricots, peaches, and pears. Another active field of work is a study of the effect of freezing on the composition of fruits and vegetables.

ETHYLENE METHOD OF COLORING CITRUS FRUITS

A method devised by the laboratory for the use of ethylene in coloring mature citrus fruits is in general use. Emphasis is placed on the need to conform to the proper conditions of temperature, humidity, and ventilation in the coloring rooms in order to secure satisfactory results when this method is used to color mature oranges and lemons. Investigation of complaints regarding lack of uniformity of color when this method was used revealed improper conditions in the coloring rooms, such as stacking the boxes of fruit too closely together on the floor, lack of proper ventilation, etc.

All chemical and physical data compiled on the effect of ethylene on the composition and color of fruits show that this gas has for practical purposes no effect on the composition of the fruit, but acts as a stimulus to the coloring processes.

PERSIMMONS

Two problems facing the persimmon industry are the determination of the proper stage of maturity and the removal of astringency. Related to the maturity problem is the effect of ethylene on the ripening processes naturally taking place in the fruit. Studies were undertaken of the effect of ethylene on the Hachiya and Fuyu varieties of fruit from the time when it was almost entirely green but well sized to the period when it was considered commercially mature. Data have been accumulated on the composition of the fruit, before and after the ethylene

treatment, and on the respiration of the treated and untreated fruit. Progressive increase in color, weight, and total sugars was noted, with decrease in moisture, insoluble solids, and total acidity as the season advanced. Changes due to the ethylene treatment were increased color in the Hachiya variety; increased soluble solids and decreased insoluble solids in the Fuyu; decrease in hardness of both varieties; and decreased astringency in the Hachiya variety.

FROZEN ORANGES

Enormous losses sometimes occur from the freezing of oranges and lemons, and as the frozen fruit can not be detected by visible inspection there is great need for the development of methods to separate it from fruit of marketable quality. The chemical changes taking place in oranges during freezing are being studied with the hope that the extent of damage may be predicted within a few days after the occurrence of a freeze, as it is very desirable to have a quick and accurate estimate of the extent of the injury.

Experimental work conducted during the year on the acidity of the juice of frozen oranges indicates greater variability in the frozen than in the unfrozen fruit.

SULPHURING OF DRIED FRUITS

Experiments to ascertain the retention of sulphur dioxide by dried peaches were undertaken in collaboration with the California Dried Fruit Association. Sulphur dioxide and moisture determinations were made on the samples collected, and the effect of heat and pressure on sulphuring was studied. The data obtained from this work will form the basis of plans for more extensive experiments for next season.

In order to obtain basic data on the sulphuring of apricots, two field stations were established at the beginning of the apricot season of 1928, one at Hanford and the other at Davis, Calif., where samples of the fruit were obtained. Determinations of sulphur dioxide and sulphur trioxide in the sulphur-house atmosphere have been made and records kept of the temperatures of the houses.

HIDES, TANNING MATERIALS, AND LEATHER

HIDES AND SKINS

Improving practices in skinning and curing.—As a part of the department's

broad program on the conservation of hides and skins, field work was started during the year on better practices in skinning and curing. So far the work has been carried on principally in Pennsylvania and largely on the handling of calfskins, interviewing producers and dealers in hides and skins, studying their practices in skinning and curing, and introducing better procedures wherever advisable. Much room for improvement is being found, particularly in regard to the composition and size of the salt used for curing. The variation in the latter factor is wide, some operators using salt that is entirely too coarse and others salt that is too fine. The reuse of unwashed, dirty, bloody salt is also frequent, and often but little attention is given to the need of prompt salting and of proper conditions of drainage, temperature, and ventilation for storage of the hides and skins during curing.

Salt stains.—Salt stain is one of the most serious and prevalent damages resulting from the curing of domestic calfskins. It is an old cause of complaint, having been recognized over 40 years ago and, although it has been the subject of much study and research, it is not thoroughly understood, and its origin is still a debatable subject. Certainly means for preventing salt stains have either not been discovered or not been applied, as is evidenced by their prevalence to-day. The study of the causes of salt stains on hides and skins and the development and application of practical means to prevent them is one of the problems on which active work has been started and will be continued during the coming year.

Hide-skinning devices.—In connection with the above work, machines and safety devices and better means for removing hides and skins without scoring or cutting them are being studied and submitted to trial in large-scale experiments.

Hide "poisons."—Assistance has been given hide dealers and tanners in supplying them with information on hide "poisons," for protecting hides and skins against insect damage during storage.

TANNING MATERIALS

Because of a continually decreasing supply of domestic tanning materials from inroads by man and diseases upon the forests, and particularly because of the doom of the American chestnut tree by the blight, attention is being given to the matter of new

sources of tannin. The development of new supplies through the cultivation of either domestic or introduced foreign tannin-bearing plants and trees or both should be actively pursued now and not postponed until the tanning industry is confronted with an acute shortage. Such studies offer the possibility of relief to the leather industry and diversity to agriculture in the form of annual or periodic supplies and crops.

Canaigre.—In this connection some attention has been given to the resurrection of the idea of growing canaigre in this country as a source of tannin. About 30 years ago this venture almost proved a success. A study of the causes of its failure and of what bearing economic and industrial developments since then might have in overcoming these causes is the first step in a resurvey of this project. Cooperative work with several firms on canaigre is in progress.

Chestnut studies.—Collaboration has been continued with the Office of Forest Pathology of the Bureau of Plant Industry in connection with studies of foreign chestnut trees as a substitute for American chestnut wood as a tanning material. Two samples of wood from Japanese chestnut trees grown in North Carolina were found to contain, on a moisture-free basis, 10 and 10.7 per cent of tannin, respectively. American chestnut wood runs from 8 to 11 per cent of tannin.

Waste hemlock bark.—Samples of hemlock bark, occurring as a waste from lumbering operations in the Northwest and exposed to salt water, have been examined. One bark had been in salt water for two years and showed 10.7 per cent of tannin; the other bark had been in salt water for but two months and showed 10.8 per cent of tannin. No conclusions with reference to the effect of immersion on tannin content can be drawn from the work so far done.

Barks from Honduras.—Several barks from Honduras, Central America, have been examined with reference to a proposal to import them into this country. Mangrove bark from this source was found to contain, on a moisture-free basis, from 34 to 37 per cent of tannin; nance bark, 27.5 per cent of tannin; and an oak bark, 22.7 per cent of tannin. These figures indicate an attractive tannin content. The tannin in our domestic barks ranges from about 11 to 16 per cent.

Ferrochrome.—In cooperation with a tanner, a few large-scale tanning experiments have been made with ferro-

chrome as a tanning agent, and plans for additional experiments are now being worked out.

Sugars in tanning materials.—Methods for the determination of sugar in tanning materials have not been satisfactory. A critical study has been made of this determination. From this work, the results of which have been published, methods have been developed and proposed for the determination of total sugars, reducing sugars, non-fermentable sugars, and fermentable sugars in tanning materials.

New extractor for tanning materials.—The metal extractors used in the laboratory are defective in that the extraction can not be watched and its completeness judged. A practical glass extractor of novel and simple construction has been designed in collaboration with a commercial firm of New York for the extraction of tanning materials and other products and is being rapidly introduced into tannery laboratories.

LEATHER

Leathers for public binding.—Active cooperation has been continued with the Government Printing Office in an effort to obtain durable bookbinding leathers. Chemical and physical examination of the leathers received during the past year by the Printing Office shows a trend toward improvement in quality since this move was started several years ago. While in general domestic-tanned bookbinding leathers do not meet the essential requirements for durability or long life, increasing interest is being shown in this subject by several tanners, to whom helpful suggestions have been given as the result of examination and analysis of their leathers.

Foreign-tanned bookbinding leathers.—In collaboration with the division of tests of the Government Printing Office, physical examination and chemical analysis of a collection of 25 foreign-tanned bookbinding leathers have been completed and the data are being assembled for publication. One of the outstanding findings of this work is the general absence of harmful or mineral acidity. Another is the use of pyrogallol tanning materials. These are two of the essential requirements for durable bookbinding leathers.

Deterioration of leather bindings.—A note on the deterioration of bookbinding leather, based on data from the examination of some old bindings from the Library of the Royal Archives, of England, has been published. These

bindings, which dated from 1480 to 1880, had been filed under very favorable conditions, especially as regards freedom from exposure to an atmosphere polluted with acidic gases and other harmful constituents, such as the air of cities and industrial centers, and were in a relatively good state of preservation. Examination of the bindings showed the leathers to be practically acid free, indicating both freedom from acidity originally or when tanned and no absorption of acids from the atmosphere during their existence. The tannages were also found to be, in general, of a pyrogallol nature. These findings offer sufficient explanation for the long life of these bindings.

Leather dressings.—Supplementing our work on old leather bindings, which indicated absorption of acid from polluted atmosphere as an important factor in their deterioration, experiments have been inaugurated on the development of dressings to help to preserve the leather through the prevention of absorption and also through the neutralization of the acids the leather may contain. Several preparations have been devised and applied to test sets of bookbinding leather. One-half of this set is being used as a control; the other half is being exposed to an atmosphere containing a known quantity of sulphur-dioxide gas. After sufficient exposure, the pieces will be examined chemically and physically and compared with the controls for a measure of the relative efficacy of the different treatments in counteracting the acidity of the sulphur dioxide and its oxidation product, sulphuric acid.

Vegetable and chrome-retanned sole leathers.—Experiments on a comparison of the properties of vegetable-tanned and chrome-retanned sole leathers are under way. A particularly interesting and valuable feature of this work is the direct comparison afforded by using alternate right and left sides of the same lot of hides in making the two types of leather. Data have been obtained in regard to these leathers on weight yields, area yields, thickness, density, tensile strength, stretch, and chemical composition. Actual wear tests are now being made to determine the wearing quality of these two leathers.

Effect of acids and alkalis on leather.—Many of the preliminary details of an elaborate experiment to show the deteriorating influence of acids and alkalis upon vegetable-tanned and chrome-tanned leathers have been worked out, including particularly the

procedure and equipment necessary to introduce into the leather known and controlled quantities of acid or alkali with a minimum resulting "edge effect," or uneven distribution, an obviously important matter in such work. Another serious difficulty in this work to which much attention has been given, with as yet but little success, is the prevention of mold growth, which will be necessary, as a part of these experiments requires storage of the leather for five years or more in high relative humidities.

Effect of oils and greases on leather.—An equally extensive experiment is under way on the merits of different oils and greases in prolonging the life and serviceability of leather and leather goods. Authentic lots of many oils and greases for this work have been obtained and analyzed, and the preliminary details of laboratory manipulation are being worked out.

Preparation of leather for analysis.—Comparison has been made of four machines in the preparation of leather samples for analyses. This is an important problem of the leather analyst because of the tough, compact nature of leather and its susceptibility to modification from heat or friction often developed in preparing the sample for analysis, especially in machines of the old, familiar coffee-mill type. The data show that not one of the machines tried seriously modifies the leather, as reflected by chemical analysis. They also suggest the possibility of using a certain recently designed mill for the preparation of all types of leather. Machines used heretofore have been designed primarily for the preparation of what are known as the heavy leathers, as distinct from the thin, pliable, light leather.

Footprint paper.—To supply a need for a practical or generally available means of registering the size of the foot, a treated paper has been developed which gives a contrasting print when the foot is rubbed over with a wet cake of soap and placed on the paper. Considerable interest has been shown in this procedure by several firms doing a mail-order business in shoes and also by clinics and hospitals in making foot records.

NAVAL STORES

Naval stores are among the major farm and forest products of the South and are valued at about \$60,000,000 annually. They are essential as raw materials of the paint, varnish, paper-size, soap, printing-ink, polish, and

other industries of the Northern and Central States. They are also largely exported.

For many years the bureau has recognized the necessity of investigations to improve the equipment and methods of cleaning and distilling gum in the production of rosin and turpentine, as well as to make an economic study of the industry. Users of naval stores stand in need of helpful work on production quite as much as the producers. Every improvement in process or product made by the producers gives the users a better material or one less difficult to work with.

GUM CLEANING

Laboratory experiments on the removal of fine dirt from crude turpentine gum by filtering both the gum alone and the gum diluted with turpentine through various materials, with and without pressure, at a temperature of 95° C. have been continued and indicate that cotton batting, even when two thicknesses of the heavier weights are used, will not hold back all the fine dirt. Cotton felt and a filter made of cellulose pulp were more satisfactory than batting. A mixture of four parts gum to one part turpentine was found to filter much more readily than straight gum, and the addition of fuller's earth to the extent of about 5 per cent was found in a number of instances to facilitate filtration. A working model of an apparatus for cleaning gum that might be tried out at a commercial still was designed and built on the basis of the laboratory experiments. Experiments so far conducted with this apparatus indicate that this process of cleaning gum will prove to be practical. Considerable interest has been shown by the industry in this line of work, and requests have already been made by leading men in the industry to have the first gum-filtration plant erected at their establishments.

STEAM STILL

Excellent progress has been made in developing the steam turpentine still designed by the bureau in 1927. While only 1 of these stills was in operation at the beginning of the year, 7 more have been installed, 3 in Louisiana, 1 in Mississippi, 2 in Florida, and 1 in Georgia. All are giving satisfactory service. From the numerous requests for plans and specifications, it is expected that many others

will be erected before the opening of the next turpentine season.

Extensive experiments have been made under the direction of bureau representatives to determine the performance of the steam still in comparison with the fire still and to establish its practicability. In these experiments an effort was made to secure gum of exactly the same nature from similar woods for comparable charges in the fire and steam stills, and everything was carefully weighed or measured. With the steam still, the yield of turpentine averaged about 1 per cent more than with the fire still. The yield of rosin was about the same for both kinds of stills, but the rosin from the steam still was lighter colored than that from the fire still. Out of 91 barrels produced in the steam still and 89 barrels produced in the fire still, the quantity of water-white rosin was 10 per cent and 5½ per cent, respectively, and the quantity of window-glass rosin was 37 per cent from the steam still, as compared with 10 per cent from the fire still. In lower grades the quantity of N rosin was 47 per cent from the steam still and 65½ per cent from the fire still, and the quantity of M rosin was only 6 per cent from the steam still, as compared with 19 per cent from the fire still. While experiments were made on all classes of gum, the outstanding showing was in the case of third-year gum, which consistently yielded N rosin on the steam still and M rosin on the fire still. In the distillation of selected scrape, the steam still produced on the average over one-half gallon more turpentine per 300-pound barrel than did the fire still. It also yielded lighter-colored rosin, that from one charge being close to window glass. The time for running a charge so as to get the best possible grade of rosin was only one and three-fourths hours for the steam still, and at least three hours for the fire still. In experiments on the use of superheated steam in the steam still, it was found that the time required for distilling scrape was greatly reduced, and the method of operating the still was simplified thereby. The steam was superheated but 75° F.

Complete detailed drawings, with specifications, were prepared for steam stills of 25-barrel and 35-barrel capacities, and for a modified steam sparger, plant layout, and still setting. Blue prints and specifications have been supplied to a large number of interested persons. A special type of

superheater that will not burn up during periods when steam is not flowing through the coils has been designed and found to be very satisfactory. A detailed drawing of this superheater will be prepared and furnished to boiler makers for the benefit of turpentine operators requiring such equipment. It is needed particularly in the distillation of scrape. Thorough tests with weighed gum of different grades showed that the steam stills have an advantage over the fire stills as regards yields, grades of rosin made, and time required for distillation. A public-service patent on the steam still has been granted.

FIELD TECHNOLOGICAL WORK

Continued interest is manifested in the educational work carried on among naval-stores producers. The bulk of the naval stores produced in this country is made at smaller places, owned in many instances by farmers in the Southern States. The possibilities for financial loss through wasteful methods of operation, insufficient and incorrectly designed equipment, and faulty handling of the finished products are numerous. The field work is performed by an experienced naval-stores man, who studies the conditions at the stills, installs better methods of production, suggests improvement in equipment, and offers suggestions for the elimination of waste. The demand for this work is far more than can be met with the force and funds available. The naval-stores technologist, because of lack of funds, was able to investigate and help only about 30 naval-stores works during the year. He delivered addresses on technological subjects before 20 meetings and associations of naval-stores interests.

TURPENTINE DETERIORATION

Spirits of turpentine has a tendency to become viscous, turbid, discolored, and rancid on aging, as do some products containing turpentine. These products, as a consequence, should be used within a few months after production. These changes often result in serious losses to producers and users. In some instances they develop with unexpected and unexplained rapidity. Experiments have been started to find a means for preventing the deterioration of turpentine during storage and in manufactured products such as shoe polishes, prepared waxes, etc. While the tests have not run

long enough for the untreated turpentine to show pronounced deterioration, the results have already developed promising and practical retardents of deterioration. The work is being continued on a laboratory scale, and at the proper time will be put to practical application.

VISCOSITY OF ROSIN

The cooperative work with producers and users of rosin has continued and has resulted in the working out of acceptable tentative methods for the determination of this property of rosin, which is becoming more and more important.

BLEACHING OF ROSIN

Experiments both in the laboratory and in the field on the bleaching of rosin have been continued during the year with promising results but have not been completed.

STATISTICS

Statistics to show the total rosin and turpentine used annually and on hand in each of the using industries, at the primary ports and the chief distributing centers at the close of the naval-stores season, March 31, 1927, and also reports on the number of new cups sold for use during the year 1927 were published during the year. These figures, which are the bureau's compilation of those voluntarily supplied it by individual users and manufacturers, are the only source of this information and serve to keep the naval-stores trade informed as to conditions. They are calculated to be between 90 and 95 per cent accurate.

MODELS

Models of the steam still, the fire still, and its setting, and of rosin strainers have been constructed and used to acquaint producers with this equipment and the best methods of installing and operating it.

NAVAL-STORES HANDBOOK

Progress has been made on the handbook to contain technical and industrial, agricultural, and general information useful to the producers. This handbook, which has been in mind for several years, is being prepared in cooperation with other interested bureaus of the department.

PAPER AND BOARD

CORNSTALKS AND STRAW

The recrudescence of general interest in the utilization of cornstalks, ba-

gasse, straw, and other farm products for paper and board making has required careful attention and much correspondence.

The work that has been done on these materials (of which there is grown annually enough to make three or four times the paper produced in this country) during the past hundred years, on two occasions by the department itself, has shown clearly that it is entirely possible to make paper and board from them. However, it has not so far been profitable to make anything but what is known as "strawboard" and "strawpaper," which have been made from wheat straw for a century in this country. It should be borne in mind, however, the making of these boards from the waste wood of the lumber and paper mills is increasing rapidly and that this raw material can probably be gathered, transported, and processed at lower cost than cornstalks. Intimate contact with industrial work along these lines has been maintained during the year. The plants engaged in the work have been visited and such cooperation as practicable extended, especially to inquirers who have been interested in these developments from the investment point of view.

In the light of our present knowledge, it is conservatively estimated that it may take as long as five years' mill-scale work, at a cost of about \$150,000 annually, to establish the practicability or rather profitability of making white paper or of separating cellulose from such raw materials. The evidence available indicates that at prevailing prices white paper can not be made profitably.

Investigations have been started on the deterioration out of doors of piled baled cornstalks, since such deterioration is likely to play a large part in the utilization of cornstalks. Small-scale laboratory experiments have been conducted with some success in making structural boards out of such farm wastes as sledded cotton burs, cornstalks, corncobs, and wild sunflower.

PAPER DETERIORATION AND PAPER SPECIFICATIONS

Work on paper deterioration and paper specifications, which have long engaged the attention of the bureau, has been continued during the year, independently and in cooperation with the Government Printing Office and the Federal Specification Board. The specifications upon which the papers for Government use are bought have

been further strengthened during the year and interest in deterioration and specification has increased. Several striking instances of the astonishingly rapid deterioration of the paper in valuable publications and documents are but confirmation of the evidence which necessitates a vigorous continuation of the work along these and related lines.

FARM FABRICS

TOBACCO SHADE CLOTH

In collaboration with the tobacco substation of the Connecticut Agricultural Experiment Station and with tobacco growers in the Connecticut Valley the bureau arranged to have about 7,000 square yards of tobacco shade cloth treated with lead chromate by a commercial treating plant to get further information concerning the value of the treatment as a light-proofing agent and concerning its commercial practicability. The treated cloth, which was sufficient to cover $1\frac{1}{4}$ acres, was put up for practical tests over growing tobacco during the 1928 season. Small-scale exposure tests are in progress to determine also the preservative effects of lighter treatments with lead chromate.

In laboratory experiments on treating tobacco shade cloth with lead chromate as a light-proofing agent it was found that a short preliminary treatment with a 0.5 per cent solution of a wetting-out agent of the naphthalene-sulphonic acid ester type facilitated impregnation to such an extent that the combined time of impregnation with lead acetate and potassium bichromate at room temperature could be reduced from about 1 hour to 5 minutes. Tests are under way to determine if there are any injurious effects from traces of the wetting-out agent left on the fabric.

GLASS SUBSTITUTES

Weather-exposure tests for five months on glass substitutes over cold-frames indicated that wire-screen cloth coated with cellulose acetate was in fairly good condition after this period; wire-screen cloth coated with cellulose nitrate was worthless, all meshes being open; two makes of paraffined cloth were worthless after exposure, being very dirty and torn through weakening of the fabric; and the same cloths with paraffin removed were comparatively clean and not torn.

SHOCK COVERS

In order to meet the need for low-priced and lightweight shock covers to protect hay and grain in the field, covers made of sheeting and drill have been subjected to waterproofing, and preservative treatments and tests are under way to determine their serviceability in comparison with canvas.

MILDEW-PROOFING MATERIALS

Mildew-proofing materials have continued to receive attention during the year. Those that have come to our attention have been subjected to laboratory tests and on their promising showing are being subjected to practical tests in the field on canvas treated therewith.

INSECTICIDE AND FUNGICIDE INVESTIGATIONS

INSECTICIDES

Injurious insects cause a loss of not less than \$2,000,000,000 annually in the United States, and their control is therefore a matter of tremendous economic significance. For a number of years chemists have been investigating some of the most important insecticides in order to devise methods for reducing the costs of manufacture and for improving their insecticidal efficacy, to ascertain with what other insecticides they are compatible, to determine the changes in their chemical composition during storage, to increase their spreading and sticking properties, and to study other problems of a physical nature.

Nicotine is one of the most valuable insecticides for controlling plant lice and certain injurious insects. It is prepared from the stems of tobacco and the sweepings from cigar factories, the better parts of the tobacco leaf being consumed in the manufacture of cigars, cigarettes, pipe tobacco, snuff, and chewing tobacco. The supply of nicotine is therefore limited and its price high. The bureau has been engaged for some time in researches looking toward the synthesis of an effective nicotine substitute, and some promising compounds have been prepared and are being tested. A compound that is even more deadly to insects than is nicotine has been isolated from crude dipyrldyl and has been designated as "neonicotine." A commercial firm has manufactured several hundred pounds of crude dipyrldyl containing "neonicotine," both as a solution and as a dust, and tests

with it against a variety of insects are being made by several entomologists in different parts of the country. The preparation and properties of "neonicotine" are described in a paper prepared for publication.

Among the nonarsenical insecticides certain fluorine compounds appear to be most promising. In order to explore the field of fluorine insecticides a number of inorganic fluorides have been prepared during the past year and are being tested against chewing insects. Samples of all fluorine compounds that are offered for sale as insecticides were analyzed, and a paper recording the results was read at the annual meeting of the Association of Economic Entomologists.

ARSENICAL SPRAY RESIDUES

The removal of arsenical residue from sprayed fruit is a matter of extreme importance as the metallic residues caused by the overspraying or late spraying of the fruit constitute a definite health hazard. In certain parts of the country the codling moth is more resistant than in other parts to arsenical sprays. For this reason it is necessary to make heavier or more frequent applications of the spray than has been customary in the past. The removal of the spray has been difficult, and in many cases apples which have been shipped, not only in interstate trade in the United States but to England and other foreign countries, upon analysis have shown an excessive arsenic residue. As a result of this the whole export apple industry, amounting in 1927 to over \$30,000,000, was jeopardized. A cooperative investigation will be undertaken during the year by the Bureau of Entomology, the Bureau of Plant Industry, and the Bureau of Chemistry and Soils to devise effective means of removing arsenical spray residue without injuring the apples. Effective substitutes for lead arsenate will also be sought. Certain oil emulsions are among the most promising of substitutes for lead arsenate for the control of the codling moth, and a thorough study is being made of these materials. A paper outlining a method for sampling apples for the determination of arsenical spray residue has been prepared for publication.

FUMIGANTS

A number of new fumigants have been developed during the past year. One of these, a mixture of ethylene

dichloride with carbon tetrachloride, which has proved to be effective against clothes moths, was brought to the attention of the public in September, and by December it was being sold at the rate of 10,000 pounds a month. This substance has never before been used as a fumigant. A manufacturer of fumigant equipment for warehouses has adopted this fumigant for use in his apparatus.

Following the announcement that the esters of formic acid were efficacious as fumigants, the production of ethyl and isopropyl formates was begun on a large scale by a manufacturer of chemicals. These substances are now being used in California to fumigate raisins.

Methyl chloracetate and ethylene oxide have been found to be very toxic to insects, and it is planned to carry on extensive tests in fumigating grain in railway cars and in bins with these compounds.

The results of investigations to find repellents for blowflies infesting domestic animals have been published.

During the year the title of "The Review of United States Patents Relating to Insecticides and Fungicides" was changed to "Review of United States Patents Relating to Pest Control." This review is now being sent to over 500 entomologists, chemists, plant pathologists, and bacteriologists in this country and abroad.

OIL, FAT, AND WAX INVESTIGATIONS

The oil, fat, and wax laboratory is studying the composition of fats and oils with a view to gaining a more accurate and intimate knowledge of them, so that they may be produced and utilized to better advantage. Fats and oils are an essential part of our diet, and many of them play an important rôle in the industries. Fats and oils from new sources are examined to discover the purpose they may serve and to determine whether or not it is feasible to produce them commercially. Investigations are also made of the more important domestic commercial oils to determine the effect of climate and soils upon the character of these products. In addition to these studies, research methods and procedures for testing the purity of fats and oils are developed.

AVOCADO OIL

The possibility of using cull avocados as a source of oil has led to a study of their composition. The oil which was obtained both by solvent

extraction and expression from the dehydrated fruit had a deep-green color, which laboratory refining and bleaching experiments failed to remove altogether. The oil had a slight fruity avocado flavor and showed good keeping qualities. It produced a pale-green hard soap somewhat similar to castile soap. Avocado oil, which belongs to the nondrying class, is similar in composition to olive oil and is characterized by its small percentage of saturated acids.

ERGOT OIL

Determinations have been made of the chemical and physical characteristics, as well as the composition, of the oil obtained by extracting a large composite sample of Austrian, Russian, and Spanish ergot with petroleum ether. Ergot oil is nondrying and is characterized by containing over 26 per cent of saturated acids as glycerides. The oil is reported to be used for the extraction of the ergosterol (which constitutes a portion of the unsaponifiable matter, amounting in this sample to about 1 per cent), the reputed parent substance of vitamin D. After the removal of the unsaponifiable matter the oil can be used in making soap.

CHIA SEED OIL

Chia, an herb of the mint family, grows wild in considerable quantity in California and is cultivated to some extent in Mexico for its seed. The latter contains an oil which, in drying power, is similar but slightly superior to that of linseed and which can be employed in the manufacture of paints and varnishes. In view of the tests made here and abroad, it appears that the oil has commercial possibilities. Also, it is probable that suitable localities for the cultivation of chia seed could be found in some of our Southern States. The investigation upon the composition of the oil, which has been in progress for several months, is approaching completion. The identity and quantity of the saturated acids, as well as of the unsaturated linolenic acid, have been determined.

METHODS

The parachloro, parabromo, and bromo-parachloro phenacyl esters of lauric, myristic, palmitic, stearic, arachidic, and lignoceric acids have been made, and their solubility in 95 per cent alcohol has been determined. The results indicate that several of

these compounds could be used for the separation of the higher from the lower members of the fatty acid series. Likewise, similar derivatives of chaulmoogric acid have been prepared, but it remains to determine their solubility. Owing to the biological interest attached to this acid in connection with the treatment of leprosy, it is desired to find some reagent that will permit its ready separation, in a quantitative manner, from the saturated and unsaturated acids with which it is associated.

An extensive study is being made of the Crismer dissolution method in connection with its further application to testing the purity of cod-liver and various vegetable oils.

NUTRITIONAL INVESTIGATIONS

PROTEIN INVESTIGATIONS

Investigations started several years ago to determine the amino acids in a number of the proteins of various foodstuffs have been completed. Formerly little was known of the chemical composition of proteins, and one protein was considered to be of equal value with another in supplying the necessary nitrogenous matter of the diet. Research has shown, however, that proteins vary materially and that the nutritive value of the proteins of foodstuffs depends chiefly upon their content of the nutritionally essential amino acids. It has shown that some of our most important foodstuffs are deficient or lacking in one or more of the amino acids necessary for animal growth. This deficiency, however, may be remedied, for feeding experiments with small animals have established the fact that when rations containing proteins of little value are supplemented by feeds having proteins rich in the necessary amino acids the mixture will produce normal growth and development.

The world production of sesame seed is approximately 700,000 tons. Sesame seed contains about 50 per cent of oil, and the press cake remaining after the expression of the oil contains about 40 per cent of protein. Practically all of the press cake is used for cattle feeding, but little information as to the value of its proteins was available until the bureau began its studies along this line several years ago. Examination of the proteins of sesame seed have been completed and two globulins isolated. One of them was obtained in the form of octahedral crystals.

Analyses of these proteins showed that they contained the nutritionally essential amino acids in sufficient quantities so that sesame press cake can be classified with protein feedstuffs that have high feeding value, and on account of its high percentage of protein of good quality it can probably be most economically utilized as a concentrate for supplementing other feedstuffs containing less protein and of poorer quality.

As compared with the proteins of other cereals those of rice have been studied but little, notwithstanding the importance of rice as an article of food. Studies of rice conducted during the past year showed that most of its proteins belong to the class known as glutelins—that is, proteins that are insoluble in water, salt solution, and alcohol. From white rice or rice from which the bran and germs have been removed, two different salt-soluble proteins (globulins) have been isolated and characterized and the percentages of the nutritionally essential amino acids determined. Polished rice contains only one glutelin.

The new method developed for the separation of the class of proteins called glutelins, by means of which it was shown that wheat glutelin consists of two separate glutelin fractions, has been further applied to a study of other cereals, including corn, oats, barley, rye, rice, and buckwheat. Two glutelins were obtained from several of these cereals, and their properties and composition are being studied.

A study of the proteins of the growing wheat plant is being made to find out in what order the different proteins present in the ripe kernel are formed and originate. The work thus far shows that the nitrogenous material in the green wheat plant is not extractable by the methods applied at present for the extraction of proteins from seeds. The nitrogen content of the press juice of the green plant at the stage approaching heading is only one-fifth of the total nitrogen present in the whole plant. After heading, but before the kernel is formed, the proportion of the nitrogen in the juice to that of the whole plant remains practically the same—one-fifth. From the salt extract of the green wheat kernel (milky stage) two protein fractions have been separated.

LIGNIN

Lignin is a substance that enters largely into the composition of plants and consequently constitutes a not in-

considerable part of the diet of herbivorous animals. Comparatively little is known regarding its structure or the part that it may play in the metabolism of animals. Herbivorous animals usually eliminate relatively large quantities of hippuric acid, the source of which is yet unknown. Lignin present in such large quantities in their food has been long suspected as the source of this acid, but no conclusive proof of this has been presented. Experiments are being conducted in which lignin is fed to animals in order to find out what part, if any, it plays in animal metabolism. Results thus far obtained indicate that lignin is metabolized and that it contributes to the formation of hippuric acid in animals.

GOSSYPOL

Feeding experiments with small animals are being conducted to test the toxicity of gossypol. Two-tenths of 1 per cent or more of pure gossypol in a satisfactory diet produced decline in weight and caused death. One-tenth of 1 per cent in the diet permitted growth at a subnormal rate, but no other visible deleterious effects on the animal over a period of more than four months. Five-hundredths per cent of gossypol in the diet produced a noticeable retardation of the growth rate. This information is of fundamental importance in connection with further work related to cottonseed poisoning in the feeding of farm animals.

VITAMINS

Experiments are being conducted to estimate the quantity of vitamins in different foodstuffs, to extend our knowledge concerning the properties of vitamins, and to develop more satisfactory methods for their assay. The determination of vitamins in oysters collected at different seasons and a comparative study of the vitamin content of certain citrus fruits with reference to genetic relationships are in progress.

Studies on the vitamin content of fresh sugar-cane juice showed that juice from the upper portion of the stalks has a higher content of vitamin B than that from the lower portion, and that juice expressed from the stalks at a high pressure has more vitamin B than juice obtained at a low pressure. Whole-cane juice contains no vitamin A or vitamin D, and the quantity of vitamin B present is too low to furnish growth at a normal rate.

Avocados were found to contain an abundance of vitamin B, but no vitamin A or D.

The bureau uses a number of young rats in its nutrition experiments. Some of the difficulties that have been met with in raising rats satisfactorily for vitamin A determination have been overcome as a result of studies carried on for the past two years. A diet regimen has been established, whereby the storage of vitamin A in young rats may be controlled and maintained at a comparatively uniform level. By means of this method the time and labor required for the determination of vitamin A in foods and commercial preparations can be materially decreased.

The general recognition of the importance of vitamins in nutrition has brought before the public a large number of so-called vitamin preparations. The realization of the value of cod-liver oil as one of the best sources of vitamins A and D has greatly increased the demand for this product, and special attention has been given to this and similar preparations on the market for the guidance of the Food, Drug, and Insecticide Administration.

SOIL INVESTIGATIONS

A. G. McCALL, *Chief*

THE SOIL SURVEY

During the fiscal year soil-survey work was in progress in 29 States on 74 different projects. On some of these projects the work had been inaugurated the previous year; on others it was begun in 1928 and was incomplete at the close of the year.

During the progress of the soil survey approximately half of the arable land of the United States has been surveyed and mapped.

A high degree of accuracy has been reached in making soil maps. Soil surveying represents the mechanics of a new science, and it has been necessary to work out methods step by step. The geological relations, the great variety of materials of different composition from which soils have developed, the various modes of soil formation, all of which have a bearing on the final characteristics of the soil, had to be worked out as these problems were met with in the field, and the whole system of soil classification gradually had to be perfected.

Each year has seen progress, and in recent years a stage of development has been reached which combines fun-

damental scientific principles with accuracy in soil classification.

In the application of the soil survey the individual is usually interested in a particular locality of limited extent. The States are interested primarily in the lands within their borders, whereas the National Government is interested in the whole country. For the sake of uniformity and in order that all interested parties may think of soils in the same terms the bureau has worked out and put into effect a system of soil classification and naming broad enough to embrace the entire country and inclusive enough to allow the differentiation of minor details.

To insure continuous adherence to the idea of uniformity in classifying soils throughout the United States and at the same time to provide for proper consideration of local conditions, it has been found desirable that Federal and State agencies should work together in making soil surveys in any particular State, with the former acting as the coordinating agency.

It is also recognized that the soils departments of the State experiment stations are best qualified to do the State's part of the work, because of their special knowledge of the soils of the State and because of the fact that all soil-fertility investigations should be closely correlated with soil classification.

For these reasons the Federal Bureau of Soils and the State experiment stations have in most cases entered into cooperative agreements for carrying on soil-survey work. In such agreements the expenses are divided equally between the two cooperating agencies.

The soil survey is of value to the individual farmer because it classifies the agricultural and the nonagricultural land and indicates soils which are best adapted to special crops and areas best suited to intensive cropping systems. It is of particular value to farmers who are seeking new locations and to city dwellers who are interested in buying farm land, and in general, for locating suburban developments or in seeking land suitable for parks or golf courses.

State agricultural experiment stations utilize the information in the reports to aid them in locating outlying experimental fields; agricultural high schools and colleges and the county agents make extensive use of the soil maps and reports in dealing with cropping systems and soil-management problems; and road engineers and factory managers use the maps in locat-

ing roads, road-building materials, and deposits of clay and other raw materials.

Another unusual but very important use which is being made of the soil-survey reports is in connection with public health and sanitary surveys made by large life-insurance companies and by banks in connection with loans made on farm lands.

The total expense of making a detailed survey of a county is less than the cost of a quarter of a mile of a modern concrete road. The actual average cost, including both Federal and State expenses, is only a fraction over 2 cents per acre. It is doubtful if there is any other line of public work of such great economic value that can be done at so low a cost to the taxpayer.

Since 1899 more than 1,100 areas have been surveyed, aggregating over 800,000,000 acres. This does not include surveys made for the Forest, Indian, and Reclamation Services and special service rendered the Department of Commerce in its rubber investigations.

Much scientific data have been collected. The characteristics of soils have been determined and evaluated, their course of development traced, and fundamental facts have been determined to make possible a scientific classification of the soils of the United States and broaden the foundation of a rational soil science.

With the reorganization of the work incident to the setting up of the new Bureau of Chemistry and Soils, it is planned to extend and more fully coordinate the work of the soil survey division with the other activities of the Federal Government and with those of the State colleges and experiment stations.

The soil survey division has been engaged in the determination of soil characteristics, in the isolation of soil types, and in mapping their distribution for many years. The work has been distributed widely over the country. Through this wide distribution an important knowledge regarding the characteristics of the soils in all parts of the country has been obtained. Very little work has been done, however, in the evaluation of the soils that have been mapped. The characteristics of these soils are known. Except for such knowledge as has been gained incidentally, the value of these types in terms of agriculture is not known. One of the necessary lines of work in order to determine this is to carry on studies in various parts of

the country, organized for the purpose of obtaining this evaluation data. Study should be carried on in each of the great soil regions of the United States. This should be conducted for a number of years, long enough to be able through the accumulated data to eliminate the accidental and temporary conditions controlling crop yields and determine the effect of the soil factor. This work should be begun now. It is not necessary to undertake to cover all the country at once, but studies can be begun in a small way and expanded as methods are worked out and soil-survey work is extended.

One phase of this work concerns the relation of soil types to the development and the spread of plant diseases.

During the past field season a limited amount of cooperative work with the division of plant pathology of Texas was undertaken for the purpose of studying the relationship of soil types to the root rot of cotton. As a result of this preliminary survey it seems certain that a very definite relation exists between certain soil types and the development and spread of this disease in Texas, and it is hoped that a continuation of this line of soil study will be of material aid in indicating the soils in which the disease will develop, as well as the characteristics of types and the particular field conditions which favor the spread of the organism responsible for this disease.

TABLE 1.—*Individual areas surveyed and mapped during the fiscal year ended June 30, 1928*

State	Area	Area surveyed		State	Area	Area surveyed	
		Square miles	Acres			Square miles	Acres
Ala.....	Mobile County.....	212	135,680	Nebr....	Clay County.....	579	370,560
	Perry County ¹	56	35,840		Hamilton County.....	538	344,320
Ariz.....	Gila Bend area.....	193	123,520		Pierce County.....	232	148,480
	Paradise Verde area.....	165	105,600		Saline County.....	462	295,680
Calif....	Clear Lake area.....	389	248,960		Thayer County.....	578	369,920
	Paso Robles area.....	1,001	640,640		York County.....	575	368,000
Colo.....	Fort Collins area.....	384	245,760	N. Mex..	Deming area.....	219	140,160
Ga.....	Cook County.....	241	154,240	N. Y.....	Nassau and Suffolk Counties ¹	359	229,760
	Elbert County ¹	191	122,240		Craven County.....	259	165,760
	McIntosh County.....	171	109,440		Davie County.....	258	165,120
	Worth County ¹	269	172,160		Gates County.....	70	44,800
Idaho....	Jerome area.....	213	136,320		Martin County ¹	152	97,280
Ind.....	Dubois County ¹	199	127,360		Person County.....	99	63,360
	Miami County ¹	142	90,880		Watauga County.....	196	125,440
Iowa....	Butler County.....	134	85,760	Ohio....	Belmont County ¹	224	143,360
	Crawford County.....	715	457,600		Butler County ¹	285	182,400
	Pocahontas County.....	482	308,480		Licking County.....	45	28,800
	Sac County.....	291	186,240		Ottawa County.....	226	144,640
	Union County.....	427	273,280		Putnam County ¹	64	40,960
Kans....	Crawford County.....	114	72,960	Oreg....	Columbia County.....	199	127,360
	Johnson County.....	266	170,240		Marion County ¹	588	376,320
	Wilson County ¹	189	120,960	Pa.....	Tioga County.....	182	116,480
La.....	Beauregard Parish ¹	533	341,120	S. C....	Williamsburg County ¹	595	380,800
Mid.....	Anne Arundel County.....	51	32,640	Tex....	Frio County.....	314	200,960
	Calvert County.....	94	60,160		Midland County ¹	260	166,400
	Cecil County.....	377	241,280		Polk County.....	194	124,160
Mass....	Hampshire and Hampden Counties ¹	321	205,440		Potter County.....	120	76,800
Mich....	Alger County.....	113	72,320		Van Zandt County ¹	434	277,760
	Branch County ¹	260	166,400	Va.....	Orange County ¹	302	193,280
	Crawford County.....	575	368,000	W. Va..	Hardy County.....	60	38,400
	Jackson County.....	707	452,480		Hampshire County ¹	257	164,480
	Kalkaska County ¹	390	249,600	Wis....	Bayfield County.....	280	179,200
	Mecosta County ¹	315	201,600		Trempealeau County ¹	320	204,800
	St. Clair County.....	245	156,800		Vernon County.....	232	148,480
Minn....	Hennepin County.....	136	87,040		Winnebago County ¹	365	233,600
	Mille Laes County ¹	227	145,280	Wyo....	Basin area ¹	359	229,760
Miss....	Hancock County.....	113	72,320		Total.....	21,838	13,976,320
Mont....	Milk River Valley area.....	456	291,840				

¹ These figures do not include portions of these areas surveyed in preceding years.

TABLE 2.—*Areas surveyed and mapped in the several States during the fiscal year ended June 30, 1928, and the areas previously reported*

DETAILED

State or Territory	Work during 1928	Work previously reported	Total		State or Territory	Work during 1928	Work previously reported	Total	
	Square miles	Square miles	Square miles	Acres		Square miles	Square miles	Square miles	Acres
Ala.....	268	51,743	52,011	33,287,040	N. H.....		1,411	1,411	903,040
Ariz.....	358	2,433	2,791	1,786,240	N. J.....		9,895	9,895	6,332,800
Ark.....		15,547	15,547	9,950,080	N. Mex.....	219	596	815	521,600
Calif.....	1,390	27,940	29,330	18,771,200	N. Y.....	359	25,712	26,071	16,685,440
Colo.....	384	3,520	3,904	2,498,560	N. C.....	1,034	39,898	40,932	26,196,480
Conn.....		1,704	1,704	1,090,560	N. Dak.....		16,878	16,878	10,801,920
Del.....		2,276	2,276	1,456,640	Ohio.....	844	14,300	15,144	9,692,160
Fla.....		15,160	15,160	9,702,400	Okla.....		6,540	6,540	4,185,600
Ga.....	872	32,443	33,315	21,321,600	Oreg.....	787	13,151	13,938	8,920,320
Idaho.....	213	10,106	10,319	6,604,160	Pa.....	182	16,721	16,903	10,817,920
Ill.....		6,770	6,770	4,332,800	P. R.....		330	330	211,200
Ind.....	341	16,507	16,848	10,782,720	R. I.....		1,085	1,085	694,400
Iowa.....	2,049	40,307	42,356	27,107,840	S. C.....	595	23,394	23,989	15,352,960
Kans.....	569	11,507	12,076	7,728,640	S. Dak.....		8,286	8,286	5,303,040
Ky.....		5,020	5,020	3,212,800	Tenn.....		11,198	11,198	7,166,720
La.....	533	16,236	16,769	10,732,160	Tex.....	1,322	48,736	50,058	32,037,120
Me.....		2,197	2,197	1,406,080	Utah.....		2,419	2,419	1,548,160
Md.....	522	11,704	12,226	7,824,640	Vt.....		1,175	1,175	752,000
Mass.....	321	7,283	7,604	4,866,560	Va.....	302	9,770	10,072	6,446,080
Mich.....	2,605	19,953	22,558	14,437,120	Wash.....		10,752	10,752	6,881,280
Minn.....	363	8,600	8,963	5,736,320	W. Va.....	317	20,213	20,530	13,139,200
Miss.....	113	29,026	29,139	18,648,960	Wis.....	1,197	23,825	25,022	16,014,080
Mo.....		37,177	37,177	23,793,280	Wyo.....	359	1,597	1,956	1,251,840
Mont.....	456	882	1,338	856,320					
Nebr.....	2,964	47,294	50,258	32,165,120	Total.....	21,838	731,869	753,707	482,372,480
Nev.....		652	652	417,280					

RECONNAISSANCE

Alaska.....		31,915	31,915	20,425,600	Ohio.....		41,420	41,420	26,508,800
Ark.-Mo.....		58,000	58,000	37,120,000	Pa.....		41,405	41,405	26,499,200
Calif.....		32,135	32,135	20,566,400	S. Dak.....		41,400	41,400	26,496,000
Kans.....		39,960	39,960	25,574,400	Tex.....	16,920	135,935	152,855	97,827,200
Mich.....		1,322	1,322	846,080	Wash.....		16,540	16,540	10,585,600
Minn.....		1,923	1,923	1,230,720	Wis.....		14,425	14,425	9,232,000
Mont.....	665	31,254	31,919	20,428,160					
Nebr.....		53,064	53,064	33,960,960	Total.....	17,585	579,938	597,523	382,414,720
N. Dak.....		39,240	39,240	25,113,600					

SOIL-FERTILITY INVESTIGATIONS

Using the soil survey as the basis, the division of soil fertility is engaged in determining the fertilizer requirements of the different soils and the application of these results to different crops and cropping systems. In addition to the work in the ordinary commercial fertilizers and mixtures, new carriers of plant-food materials from various sources are tested, both in the field and in the laboratory.

During the past year there have been placed upon the market from abroad a great number of new materials about which there is insufficient information concerning their effect upon crop plants under North American conditions. The fertilizer industry, State experimental stations, farmers' organizations, and farmers themselves are pressing for authentic

information, which can be secured only by means of well-controlled experimental work conducted under local field conditions. It is essential that the different fertilizer materials be studied not only from the viewpoint of increased yields but also as to their effect upon keeping qualities, color of fruit, and other characteristics.

SOIL-CHEMISTRY INVESTIGATIONS

Under the agricultural appropriations act the chemical laboratory is charged with the duty of making investigations of the soil with reference to their chemical composition and mineral content, and of studying the chemical properties of soils in their relation to soil formation, texture, and productivity. In addition to the large number of routine analyses made in connection with the samples collected by

the soil survey, this laboratory is devoting considerable time to a study of the exceedingly fine particles, known collectively as soil colloids. Studies dealing with this colloidal material have shown that laboratory examinations of soils can be used for predicting how they will behave under given cropping systems and in certain engineering projects, such as road building.

The results of the large number of examinations that have been made for individual farmers and for other branches of the Government service have been used in the prosecution of land frauds, in detecting localities where concrete tile would disintegrate, in determining the causes of crop failures, and in judging the adaptability of soils to certain crops and their probable response to cultural treatments.

It is quite important that both these lines of work should be enlarged if the soil divisions of the bureau are to function most efficiently. More samples should be analyzed for soil-survey work than is possible with existing facilities, and the work on other projects could be considerably advanced if it were possible to carry on more chemical work. Also, there should be a substantial increase in the investigations of soil chemistry. Studies of the fundamental nature of soil constituents and soil processes are needed, and improved methods of soil examination must be devised if practical problems, such as soil erosion, are to be solved. The recent studies of the colloidal soil material demonstrate this. This bureau is the only governmental agency directly concerned with such investigations, and other Federal and State institutions naturally look to the bureau for the latest information.

SOIL-PHYSICS INVESTIGATIONS

Closely correlated with the chemical work, the soil-physics laboratory conducts investigations of the important physical properties of the soil, such as moisture relations, aeration, heat absorption, texture, and the physical effects of different amounts and proportions of colloidal material. Knowledge gained in this work of the physical properties of soils and the methods for their measurements is essential to their classification and agricultural utilization and is useful for such purposes as the construction of roads, dams, levees, and general engineering projects.

During the present fiscal year mechanical analyses have been made for the Bureaus of Public Roads, Plant Industry, and Entomology, and the Forest Service, as well as for experiment stations, universities, engineers, and agronomists. Experimental work on new methods has also been in progress, and determinations have been made of moisture equivalent, wilting coefficient, soluble salts, volume weight, and Atterberg plasticity constants. Studies are being made of soils having varying susceptibilities to erosion, in an effort to determine what relationships exist between erosivity and other physical properties of soils. Through cooperation of the Navy Department and the Fixed Nitrogen Laboratory of this bureau, a Wood & Loomis supersonic oscillator is being installed at the American University laboratory. This apparatus will be used by the divisions of fertilizer investigations, soil chemistry, and soil physics. Studies will be made on the effect of high-frequency, high-intensity sound waves on the dispersity of soil material. It is anticipated that this will be used to isolate soil colloids for further chemical and physical investigations. There is urgent need for an increased amount of research work in this laboratory. Soil physics is now the weakest link in the chain of soil research not only in the Department of Agriculture but in the State experiment stations as well.

SOIL MICROBIOLOGY

The division of microbiology is devoted to a study of the soil population, which includes such microscopic forms as bacteria and the larger organisms, such as fungi and molds. In addition to these fundamental studies the laboratory distributes legume bacteria cultures, for experimental and demonstration purposes, through the Extension Service and in cooperation with the State experiment stations. During the past year about 25,000 cultures were sent out at the request of Congressmen, county agents, farmers, and investigators located in all parts of the United States. In the emergency situation created by the recent overflowing of lands in the lower Mississippi Valley this laboratory is assisting in the re-establishment of the legume crops by supplying the proper bacteria to the county agents in the flooded areas. In addition to this distribution service, an annual inspection of the several brands of commercial bacterial cultures sold in the United States is made,

in order to protect the farmer and others against unscrupulous dealers and manufacturers.

Since the inclusion of this work in the Bureau of Chemistry and Soils there have been tested, or are in the process of being tested, 31 brands of commercial inoculating materials and 15 types of material from agricultural institutions. Legume bacteria culture tests are usually made in duplicate on five strains of each brand of cultures, including, as a rule, nodule bacteria from alfalfa, red clover, cowpeas, soy beans, and vetch, and legumes related to these from a nodule-producing standpoint. On the average, about eight units are obtained in each official sample. Each unit is homogenized, diluted, and plated to determine the numbers of legume nodule bacteria present and the extent of contamination, if any. Part of the material from each unit is used in treating seed to determine whether the organisms contained in it are efficient from a nodule-producing standpoint. This requires that sterilized seed, and sterilized media in bottles be prepared, inoculated, placed in the greenhouse, and after about two months' growth be examined for the production of nodules. Some field work is done in connection with the testing of certain strains of legume bacteria cultures.

The information obtained from these tests is given to authorized persons in agricultural institutions when requested and is given to the public in the form of an annually revised sheet showing a list of sources from which inoculating material may be obtained.

In the case of biological fertilizers which include sulphur, peat, and other inoculated preparations which appear on and disappear from the market from time to time, claims are usually made on the basis of the organisms they are purported to contain, and special tests are used to determine the efficiency of the organisms in comparison with those in fairly fertile soil. It is significant that in all these tests made on various products of this type the organisms of fertile soil have proved superior to those in cultures. When conditions warrant, information obtained in these tests is made available in periodicals or to county agents in the regions in which the material is being sold.

A study is being made of the relationship of carbohydrate to nodule formation and nitrogen fixation by legumes. This study has for its aim the determination of the operation of at least one of the fundamental factors

concerned in the important economic process of nitrogen fixation by legumes. It has been found already that by limiting the light or the leaf surface, nodule formation can be modified.

MUCK AND PEAT INVESTIGATIONS

Peat-land and muck-land investigations were inaugurated in the Bureau of Plant Industry in 1915 with a preliminary survey of some of the fundamental differences between peat and muck. With the advancement of our knowledge of the botanical composition of plant remains and of the stratigraphic features of peat areas, it has been possible to adopt more refined methods of study and classification of this important agricultural resource. Since the transfer of this work to the Bureau of Chemistry and Soils, steps have been taken to enlist the cooperation of the States in the working out of a comprehensive national plan for peat-land utilization.

The work now in progress includes the mapping of local and regional areas of peat; studies of the character of the surface vegetation; profile soundings to determine the nature of the vegetation of former periods that has contributed to the present formation; laboratory studies of botanical, chemical, and physical characteristics of samples from typical areas in different geographic regions; and finally the establishment of cooperation with the States with a view to coordinating the work of inquiry and research on a broad national basis.

SOIL EROSION

Continued observations and additional information collected during the past year serve to confirm our previous convictions that both hillside and sheet erosion are a serious menace and among the most active factors in the deterioration of farm lands.

The insidious processes of soil erosion have not been confined to the boundaries of the older Eastern States but have extended over the rolling parts of the fertile prairie States. Probably not less than 10,000,000 acres of land formerly cultivated has had its productive capacity permanently impaired by rainwash. Much of this land could have been saved by timely terracing and judicious cropping.

The bureau recognizes the immediate need for fundamental data relating to the factors concerned in soil erosion and is taking steps to collect information upon which to make recommendations looking to an effective

tive control of this menace. An evaluation of all soil surveys is being made in order to gain a better conception of the distribution and the extent of all the more vulnerable soil types and to secure an inventory of the areas that are better suited to forestry or grazing than to the production of farm crops. In this work the cooperation of the States is being sought, with a view to establishing local experimental fields upon which to study the relative erosivity of different soil types, the effectiveness of different methods of terracing, and the extent to which cropping systems may be employed to minimize the destructive effects of rainwash.

In this connection studies are being made of a number of samples of easily eroded soils to determine what physical difference, if any, exists between these soils which readily erode and those which do not easily wash or gully. It is hoped that the results of these tests will furnish important information to the agricultural engineer in his attempts to plan erosion controls suited to particular fields, slopes, and localities.

FERTILIZER AND FIXED NITROGEN INVESTIGATIONS

F. G. COTTRELL, *Chief*

The growing appreciation of the essential nature of fertilizers in agriculture, as agents for conserving soil fertility and increasing farm profits by effecting the reduction of acreage cultivated and the increase of yields per acre and per man power, demands an increasing fund of fundamental data with which to proceed to the enlargement of domestic supplies of fertilizer ingredients and the termination of dependence on foreign sources. This enlargement of domestic supplies of fertilizers can be accomplished through the more efficient utilization of domestic raw materials, the development of new compounds, and the transformation of old compounds into more useful forms, all with improved technology and economy. The impending transition of the fertilizer industry to a chemical basis, as illustrated by domestic and particularly foreign changes, implies an obligation that modern chemical science be placed at the service of the industry to anticipate demands for fundamental technical data on a wide range of pertinent subjects.

AMMONIA SYNTHESIS

Since the fixation of atmospheric nitrogen by the chemical combination of nitrogen and hydrogen under high pressures and in contact with catalytic agents remains the keynote in modern fertilizer developments, that field of research has been continued and somewhat broadened. During the year progress has been made in ammonia synthesis through a study of the mechanism of catalysis, to which have been applied chemical, physical, and mathematical methods. The molecular arrangement of catalyst surfaces, as revealed by X-ray methods, and their electrical properties have sufficient bearing on the chemical reactions induced by catalytic agents to warrant more intensive research with these methods. Catalysts of greatly increased efficiency in the production of hydrogen from water gas and steam have been developed and their commercial value indicated. The purification of hydrogen from carbon monoxide by catalytic oxidation has been compared with purification by established methods. The behavior of iron catalysts in ammonia synthesis has been further studied under varying conditions, as determined by the temperature, pressure, composition, and impurities of the gas mixtures employed. Special attention has been given to the mechanism of the action of two types of iron catalysts for ammonia synthesis, of cobalt catalysts for the production of hydrogen from water gas, of copper-oxide and manganese-dioxide mixtures for the separation of carbon monoxide from hydrogen by selective oxidation, of cobalt or nickel catalysts in the production of hydrogen from methane and steam, and of catalyst poisons in ammonia synthesis at high pressures. The characteristics of the nitrogen atom, as revealed by nitrogen linkage in azo and diazo compounds and by band or molecular spectra, are being studied.

NITROGEN FIXATION BY ORGANISMS

To gain additional information on the nitrogen fixation processes taking place in nature through the instrumentality of organisms, studies have been continued with symbiotic and non-symbiotic nitrogen-fixing bacteria. Since it has now been shown that *Bacillus radiculicola* apparently has little or no power to fix nitrogen in the absence of the host and further that the juices extracted from the host

plant are highly stimulating to the growth of these bacteria, research is being conducted to determine the nature of this stimulant and its function in symbiosis and nitrogen fixation. An effort is being made to determine whether ammonia is the first product of nitrogen fixation by the nonsymbiotic organisms and to determine the function of enzymes in that synthesis.

HIGH-PRESSURE STUDIES

Ammonia synthesis, as applied industrially, involves gas pressure so high as to exceed the range over which known data apply. To know the behavior of single and mixed gases at high pressure is essential to correct engineering practice. The determination of the physical constants of gases at high pressures has been continued with a study of the compressibility of hydrogen, nitrogen, and a 3:1 hydrogen-nitrogen mixture at pressures to 1,000 atmospheres and temperatures from 0° to 400° C., and of a 3:1 hydrogen-nitrogen mixture containing ammonia, and of pure carbon monoxide. The solubility in water of a 3:1 hydrogen-nitrogen mixture at 25° C. and at pressures to 1,000 atmospheres has been determined, also the viscosity of compressed gases. The physical properties of compressed nitrogen have been calculated from compressibility data. The engineering involved has included the design, construction, and installation of three compression systems, for the development of gas pressure to 1,500 atmospheres, and auxiliary apparatus and equipment for the study of gases at these pressures and at temperatures to 400° C., including dead-weight and floating piston dial gauges, relief valves, a high-pressure booster compressor, and a carbon-monoxide generating and compressing system.

The deteriorating effect of gases at such pressures on materials of construction is of such fundamental engineering importance that research has been continued to determine the metals and alloys most resistant at a prolonged pressure of 9,000 pounds and a temperature of 300° C.

NITROGENOUS FERTILIZER MATERIALS

The transformation of synthetic ammonia into nitrogen compounds of chemical and physical properties best adapted to fertilizer use is a research of fundamental importance which has been continued, special emphasis being placed on urea synthesis, the oxidation of ammonia to nitric acid, and the

absorption of ammonia to form the more desirable salts.

UREA

Among the nitrogenous fertilizer compounds none is more highly concentrated than urea, which contains 46 per cent nitrogen. Its synthesis from ammonia and carbon dioxide has potentially great industrial importance. To reduce its manufacturing cost through improving the yield obtainable, the mechanism of the reaction involved has been further studied. A method has been devised for determining the state of combination of water in the converted charge, and the liquid areas have been charted on the triangular diagram by means of melting-point determinations in the three-component system—ammonia, carbon dioxide, and urea. Equilibria which have been determined in the carbamate-ammonia system show that at 150° C. and in the presence of an ammonia excess of 100 per cent, the efficiency of the carbamate-dehydration reaction is increased to 70 per cent as compared with 40 per cent, the maximum formerly obtainable. Definite progress has been made in the further development of a pilot plant for the experimental and demonstrational manufacture of urea. Preliminary operations involving the pumping and measurement of liquid ammonia and liquid carbon dioxide, their introduction into a high-pressure autoclave, and the discharge of the reaction products, have been successfully carried out. A new method has been devised for reducing the hygroscopicity of urea, the present greatest deterrent to its use.

NITRATES

The oxidation of ammonia as a source of nitrates has been studied further by comparing the platinum catalyst with cobalt and bismuth, which demonstrated the superiority of platinum on the basis of both efficiency and cost. Apparatus for controlling the explosive oxidation of ammonia with pure oxygen has been successfully developed, providing for the efficient production of liquid nitrogen peroxide, a source of concentrated nitric acid, and nitrogen trioxide, a source of nitrous acid, products of great importance in industrial chemistry, national defense, and agriculture. Equilibria involved in the reaction whereby nitric oxide is absorbed in potassium-chloride solution to form potassium nitrate and hydro-

chloric acid have been studied in both gaseous and liquid systems, from the viewpoint of a continuous process. Further work has been accomplished in improving the methods of preparation of the ammonium phosphates. The chemical and physical properties of these important new fertilizer compounds have been studied.

PHOSPHATES

The production of fluorides as a by-product of the phosphate industry has gained importance through the increased use of these compounds as insecticides. A survey has been made of the fluorine content of phosphate rocks to determine the potentialities in this direction. Liquid phosphoric acid remains the most promising of fixing agents for ammonia, as such being in a sense the basis of the concentrated-fertilizer program. Accordingly researches looking to its cheap production have been continued to determine the mechanism of the reactions underlying the reduction of phosphates by carbon, on the one hand, and on the other blast-furnace principles have been applied to determine the effect of such variables as furnace diameter and height, blast temperature, oxygen content of blast, rate of blowing, time, and temperature. Thermal efficiencies and slag characteristics have been measured. Two experimental blast furnaces have been operated, and a third, embodying the developments indicated by the results of the first two, is now under construction. Substantial progress, it is felt, is being made toward the solution of the problem of the cheap production of liquid phosphoric acid.

Further progress has been made in the decomposition of phosphate rock by nitric oxide, which shows that a satisfactory absorption of the oxides and decomposition of the rock can be accomplished in one operation with the formation of a product containing both available phosphoric acid and calcium nitrate. The economies thus effected over methods employed in the past lend potential importance to this process and product.

POTASH

While the potash imported from Europe shows a decline in tonnage, due to increasing prices it still represents an annual expenditure of \$18,000,000. Rapid progress is being made in the development of the American industry, an increased production of 85 per cent having been registered during the

year. New potash raw materials have been placed under exploitation. Progress has been such as to warrant confidence that present developments will be continued to a point where national independence with respect to this fertilizer essential will be achieved. Present researches are conducted with a view to the concurrent production of side products to cover the costs of the potash extraction, for the prime essential is that potash be cheap. The greensand deposits of New Jersey and Texas continue to be the largest potential sources so far discovered. The by-products afforded in extraction methods so far developed, both from this and other raw materials under study, would tend to make potash recovery an integral part of other industry. Effort accordingly is being made to effect a tie-in with the major industries with a view to greater production. From this viewpoint the experimental blast furnace has been adopted as a means of liberating potash from its ores as an operation incidental to the manufacture of phosphoric acid and other fertilizer products. While the main objective has been agricultural potash in high concentration to reduce transportation costs, the possibility of developing cheap processes for producing other and relatively low-grade products has not been overlooked.

CONCENTRATED FERTILIZERS

The present trend in fertilizer manufacture is toward the more concentrated mixtures which make possible substantial reductions in transportation, sacking, and handling costs. These fertilizers, in turn, call for more concentrated ingredients, fertilizer salts in which nitrogen, phosphoric acid, and potash are combined with the minimum of nonfertilizing elements. An essential of mixed fertilizers being their free-flowing and noncaking properties, studies are made of the chemical and physical properties of the new salts, their interaction when mixed, and their behavior in storage and in the fertilizer drill. Granulation and other methods have been devised for improving their drillability and for reducing their hygroscopicity. Studies have been made of commercial drills to determine their adaptability to the accurate distribution of fertilizers demanded by the new, highly concentrated materials. A simplified system for computing fertilizer mixtures from concentrated materials has been completed.

ANALYTICAL CHEMISTRY

Contributions of general interest have been made in analytical chemistry as applied to the volumetric and gravimetric analysis of phosphates. A new method has been developed for the determination of fluorine in phosphate rock. Service has been rendered the public in the analysis of fertilizer raw materials. Of especial value has been the service rendered by the analytical laboratories to the research units in providing analytical data concerning intermediate and final products.

ENGINEERING

Essential contributions to the work of the unit have been made through the design, construction, and installation of glass, electrical, and mechanical equipment, some of it of extreme delicacy and intricacy and covering a wide range of applications, from high-pressure compressors on the one extreme to instruments of precision on the other.

INFORMATION SERVICE

Services have been rendered to outside interests through correspondence and conference on a wide range of pertinent subjects, thus placing the results of research at the service of the public. Information has been supplied to Congress on the Muscle Shoals problem and to other governmental agencies as demands have arisen. Collaborations have been established with other units in this and other departments with a view to the acceleration of the public work.

**PUBLICATIONS OF THE BUREAU OF
CHEMISTRY AND SOILS ISSUED DURING
THE YEAR JULY 1, 1927, TO JUNE 30,
1928**

TECHNICAL BULLETINS

No. 1. Tests of Methods for the Commercial Standardization of Raisins.

No. 20. A study of Phylloxera Investigations in California as Related to Types of Soils.

No. 64. Bacteriology and Chemistry of Oysters with Special Reference to Regulatory Control of Production, Handling, and Shipment.

No. 74. The Value of Inert Gas as a Preventive of Dust Explosions in Grinding Equipment.

No. —. The Deterioration of Structural Steels in the Synthesis of Ammonia.

¹ Bureau of Standards Technical Paper, No. 361, of which J. G. Thompson and J. S. Vanick, of the Bureau of Chemistry and Soils, were coauthors with W. W. de Sveshnikoff of the Bureau of Standards.

DEPARTMENT BULLETINS

No. 1373. Dust Control in Grain Elevators (a revision).

DEPARTMENT CIRCULARS

No. 7. An Apparatus for the Rapid Vaporization of Carbon Bisulphide.

No. 33. Soil Erosion a National Menace.

No. 35. The Commercial Production of Sauerkraut.

No. 419. Grouping of Soils on the Basis of Mechanical Analysis.

No. 423. The Use of the Electrolytic Bridge for Determining Soluble Salts.

JOURNAL OF AGRICULTURAL RESEARCH ARTICLES

Variation of the Colloidal Material in Typical Areas of the Leonardtown Silt Loam.

An Observed Case of Spontaneous Combustion in Farm Products.

Effect of Hydrogen-Ion Concentration on the Absorption of Phosphorus and Potassium by Wheat Seedlings.

SOIL SURVEYS

Burt County, Nebr.

Douglas County, S. Dak.

Genesee County, N. Y.

Grant County, S. Dak.

Worcester County, Mass.

Gilroy Area, Calif.

Polk County, Oreg.

Monroe County, Ind.

Hollister Area, Calif.

Appanoose County, Iowa.

Clermont County, Ohio.

Perry County, Miss.

Green Lake County, Wis.

Fulton County, Ohio.

Yadkin County, N. C.

Plymouth County, Iowa.

Lawrence County, Ind.

FARMERS' BULLETIN

No. 921. Liming of Soils (a revision).

YEARBOOK ARTICLES

Soil Bacteria of Two Main Groups Fix Air Nitrogen.

Potash Industry is Progressing Despite Foreign Competition.

Fertilizer's Utility Much Affected by its Mechanical Condition.

Phosphoric Acid of Higher Concentration got by New Methods.

Nitrogen from the Air Fixed as Plant Food Mainly by Bacteria.

Sugar-Cane Cream a New Product of Commercial Value.

Soil Erosion Takes \$200,000,000 Yearly from United States Farmers.

Citrus By-product Plants Cut Waste and Sustain Prices.

Footwear Made Water Repellent by Various Modes of Treatment.

Soils as Well as Plants React to Fertilizers Used.

Beets Given Phosphate Make Larger Yields and Have More Sugar.

Tung-Oil Tree Does Best in Southeast Coastal Regions.

Oysters Are High in Food Value; Vitamin Content Exceptional.

Peanuts a Valuable Food for Man and Feed for Livestock.

Fruit Flavors Due Principally to Free and Volatile Acids.

Soil Moisture is an Important Factor in the Tillage of Land.

Lignin Experiments Show Some Uses for Many Farm By-products.

Fire Loss on Farms, \$150,000,000 Property and 3,500 Lives a Year.

Turpentine Distilling by New Steam Still has Many Advantages.

Chemists in Front Ranks in Warfare on Harmful Insects.

Manganese, Needed by Plants, is Deficient in Some Soil Types.

Chemists Explore Ways to Utilize By-products Now Called Farm Wastes.

Soil Acidity Helps some Plants; Others Require Alkalinity.

Wheat Protein is Increased by Using Nitrate at Heading.

Chemist's Field in Agriculture almost limitless in Scope.

MISCELLANEOUS

Review of United States Patents Relating to Pest Control, from April, 1927, to April, 1928, inclusive.

One hundred and sixty-five articles in trade and scientific journals.

DEC - 3 1928

EXPERIMENT STATION FILE

BDIM-435

REPORT OF THE CHIEF OF THE BUREAU
OF DAIRY INDUSTRY

United States Department of Agriculture,
Bureau of Dairy Industry,
Washington, D. C., August 31, 1928.

Sir:

I have the honor to submit herewith a report of the work of the Bureau of Dairy Industry for the fiscal year ended June 30, 1928.

Respectfully,

L. A. ROGERS,

Acting Chief of Bureau.

Hon. W. M. Jardine,
Secretary of Agriculture.

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On January 1, 1928, Dr. C. W. Larson, chief of the Bureau of Dairy Industry, resigned to become Director of the National Dairy Council. Since that date the activities of the bureau have been under the direction of Dr. L.A. Rogers, acting chief, in charge of the dairy research laboratories. No change in the policies of the bureau has taken place. Much attention has been given to research work on problems fundamental to the industry. Consideration has also been given to the introduction of new methods that have been proved successful by both laboratory and field tests.

DAIRY RESEARCH LABORATORIES

L. A. Rogers, In Charge

Milk Secretion and the Nutrition of Dairy Cows

The investigation to determine the relation of phosphorus to milk secretion has been continued. Cows giving 50 to 60 pounds of milk daily on rations containing concentrates, mangel beets, alfalfa hay, and enough disodium phosphate to maintain an optimal relation between the calcium and phosphorus in the ration were found to be losing calcium and phosphorus from their bodies. These results are in contrast to those reported last year, when cows giving 40 pounds or less of milk were found to maintain a positive calcium balance. Exercise in sunlight did not prevent a loss of calcium and phosphorus in the case of cows giving 50 to 60 pounds of milk daily but did bring about a loss of nitrogen.

Strength tests of the bones of cows fed for extended periods on alfalfa or timothy hay have shown that bones from cows fed timothy were 10 to 20 per cent lighter than those from comparable cows fed alfalfa.

During the past year extensive work has been done, partly in cooperation with the laboratory of physiological chemistry of Yale University, on the origin of cystine and other sulphur compounds of milk. In order to establish the source of these constituents of the milk and to trace their connection with the protein of the feed, it has been necessary to identify certain sulphur compounds of the blood which earlier work has shown are removed from the blood when it passes through the mammary gland. About 2 tons of pig's blood has been utilized in obtaining a sufficient quantity of the sulphur compound to permit definite identification. Two sulphur compounds have so far been prepared from blood, one of which is apparently glutathione associated with some substance from which it has not been separated. The second is fairly pure ergothioneine, but the latter occurs in cow's blood in only very small quantities.

Bacteriology and Chemistry of Milk

In a study of the proteolytic bacteria of milk a medium has been devised for the direct isolation of caseolytic bacteria. The bromine test for tryptophane has been shown to be efficient in the detection of caseolysis in milk or casein media. In these investigations it has been found that while some of the organisms apparently decompose lactalbumin to some extent, a considerable increase in the formol titration figure may be due to decomposition to ammonia of the urea in the serum. The actively caseolytic aerobic spore-forming rods produce little increase in amino nitrogen in the serum and not much ammonia.

Work during the past year has demonstrated that with all other conditions favorable the lactic fermentation of typical bacterial cultures is finally checked by a soluble and diffusible substance produced by the growth of the cells. The same substance or a similar one acts in suppressing or retarding the growth of other bacteria when grown in mixed culture with St. lactis. St. lactis retards Lact. bulgaricus even when the two cultures are separated by a permeable membrane. This explains why it is difficult to develop a high acidity in buttermilk by inoculating with bulgaricus.

Earlier results on the accuracy of plate counts have been confirmed. It has been demonstrated that by observing the laws governing the growth and death of bacteria and by reasonably careful technique accurate bacterial counts may be obtained.

Preliminary experiments have shown that a marked increase in the numbers of thermophilic bacteria can take place in the foam in the holder vat of a pasteurizer and that this foam can increase the numbers of bacteria in the milk below.

When bacteria grow in milk or other fluid media they change the oxygen tension. This produces a definite electrical potential which can be measured and used as an indication of the extent of the bacterial growth in the medium. Reduction potential curves have been established for a number of the common acid-forming bacteria of milk. All the streptococci bring the potential to practically the same level. Final values for the lactobacilli are at a somewhat different level from that found for the streptococci but agree well with one another. The effect of temperature has been established for L. acidophilus and L. bulgaricus. Differences of temperature within the growth range affect the rate of change of reduction potential but not the final value.

Condensed and Evaporated Milk and Dried Skim Milk

The effects of different temperatures and durations of time of forewarming milk and cream upon the heat stability of its evaporated product show that in the case of milk a forewarming temperature near the boiling point produces maximum stability of the product, whereas with cream of 20 per cent butterfat heating to 80°C. or forewarming to 70° - 74°C. for 30 minutes produces maximum stability and a product that is sterilizable.

Forewarming conditions and homogenization pressures as well as acidity factors have been shown to be definitely related to feathering of cream, and the conditions for overcoming this trouble have been determined.

A method for obtaining large quantities of milk serum has been devised, and the Ca and PO_4 contents of the serums of milks heated to various forewarming temperatures have been determined. No definite relationship has been found to exist between the variations in the concentrations of these ions and the time of coagulation.

In an attempt to contribute to the knowledge of the acid-base equilibria of milk and to explain certain chemical and physical changes which take place in milk, both under spontaneously induced conditions and under manufacturing treatments, buffer curves have been determined on raw milk, autoclaved milk, milk intermittently steamed, natural sour whey, rennet whey, grain curd casein whey, forewarmed milk, lactate solutions, and casein suspensions. Considerable differences have been found in buffer intensities at various hydrogen-ion concentrations.

The effect of the use of dried skim milks upon baking quality of a variety of soft- and hard-wheat flours has been studied. Marked improvement was noted in all cases when the resulting loaves were judged by volume, break, shred, color of crust, texture, crumb, and absorption. The hard spring wheat flours responded most readily to the effect of dried skim milk.

Dried skim milks prepared from milk heated to 50° , 63° , 73° , 83° , 93° , and 100°C . for 30 minutes respectively have been used in doughs prepared from hard spring, hard winter, and soft winter wheats. Marked improvement in the loaf was noted in the case of each flour with the greatest improvement in the soft winter wheat flour. Dried skim milks prepared from milk heated to 73° , 83° , 93° , and 100°C . were practically on a par in ability to improve baking quality, and all were far superior to those made from milk heated to 50° or 63°C .

The Bidwell-Sterling toluene distillation method for determining moisture in dried skim milk has been tested and found preferable to the vacuum-oven method.

Ice Cream

The relationships of homogenization pressure and temperature to the basic viscosity and overrun have been studied. In general the higher the homogenization pressure the higher the basic viscosity. With increase of homogenization temperature there may be a decrease in basic viscosity or there may be an increase followed by a decrease in the basic viscosity. In the former case it has been found that it is apparently possible to alter the basic viscosity of an ice-cream mix by varying the temperature of homogenization without changing any of the other factors that may affect the whipping ability.

Investigations of the solubility relationship of lactose-sucrose-water solutions at 0°C. and -3°C. show that the solubility of lactose is cut in half in saturated cane-sugar solutions.

In a series of experiments in which dried skim milk was used as a source of milk solids not fat it has been shown that if the dried skim milk is fresh and made from milk heated to a relatively high temperature, the quality of the ice cream is actually improved both in texture and flavor.

Cheese Investigations

The work during the past year has been for the most part on the control of the texture of Swiss cheese. The rate of ripening of the milk, as indicated by the soluble nitrogen content, is not correlated with the texture. The results obtained indicate that the moisture content of the cheese has a direct relation to the texture. Paraffining the cheese before removal to the warm room had a distinctly favorable effect in improving the texture and decreasing the glass.

It has been found that the rate at which the hydrogen-ion concentration develops in the cheese on the press is correlated with the texture and to a less degree with the moisture content. A rapid increase in hydrogen-ion concentration almost invariably results in a cheese with a texture inferior to that of a cheese from the same milk in which a

slower development of acidity was induced. This can be controlled by the selection of cultures used as starters.

Investigations have shown that pressler and niszler fermentations in Swiss cheese are usually caused by the same organism. The form which the fermentation takes is determined by the stage of development of the gas-forming bacteria at the time it is exposed to the high temperature of the making process. If the cells are in the actively growing stage and consequently, as shown by earlier investigations, more sensitive to heat, the greater number are killed by the high cooking temperature and the gassy fermentation may be prevented or minimized. On the other hand, if the cells have passed the period of logarithmic growth and are in the more resistant stage they survive the cooking temperature and begin a new development when a favorable temperature is reached as the cheese cools on the press.

By application of the same principles to the acid-forming culture in Swiss-cheese making, it is possible to adjust the age of the culture so that a maximum development of the cells takes place after the cooking process and the abnormal fermentations are suppressed.

A gassy fermentation of process cheese containing pimentos has been found to be due to the fermentation of a carbohydrate contained in the pimentos. In laboratory experiments the fermentation was entirely suppressed by washing the pimentos to remove the fermentable carbohydrate, but under factory conditions this method was not successful unless the moisture content of the processed cheese was held relatively low.

Utilization of By-Products

Methods of separating albumin and lactose from whey are being studied. The effect of the variation in the composition of whey on the recovery of lactose has been determined. It has been shown that lactose may be recovered directly from neutralized and condensed whey provided a neutralization precipitate does not appear when the acidity of the whey is reduced. The neutralization precipitate

formed by neutralizing whey having an acidity greater than 0.2 per cent has been identified as tricalcium phosphate and protein material. The quantity of the precipitate formed increases with a decrease in hydrogen-ion concentration, as does also the ratio of tricalcium phosphate to protein material.

Work has been started on some of the factors which influence the quality of cultured buttermilk. Accurate methods have been designed for determining the viscosity, stability, and other physical properties of the product. Some of the manufacturing details which affect these properties, as for instance, the temperature of pasteurization, have been determined.

DAIRY-CATTLE BREEDING INVESTIGATIONS

R. R. Graves, in Charge

The Beltsville Experimental Breeding Herd

Progress of the Linebreeding - Outbreeding Project

During the past year, Denton Colantha Sir Rag Apple, the first outbred sire used in this project, became sterile at the age of about 17 years. During his period of service at Beltsville he sired 37 female offspring, 32 of which are still in the herd. Only 3 of the original foundation cows to which this bull was mated are now in the herd.

The second outbred sire, Varsity Derby Matador, has been mated to 31 daughters of Denton Colantha Sir Rag Apple; and the 10 daughters dropped to his service during the past year raises the total of the second outbred generation females to 19. Eight additional cows and heifers are pregnant to his service. This bull is 12 years old and is still fertile.

Pride of the Bess Burkes, the third outbred sire, was placed in service at Beltsville in January, 1928, after being used for 10 months in the Huntley herd. Six daughters of Varsity Derby Matador are now pregnant to his service. Pride of the Bess Burkes is a proved sire and has 18 daughters with official production records averaging 17,131 pounds of milk and 589 pounds of butterfat at 3 years 2 months of age.

The linebreeding part of this project got under way this year when the young bull, Sir Gerben Colantha Rube, was ready for service. He is a son of Varsity Derby Matador and out of a daughter of Denton Colantha Sir Rag Apple. Sir Gerben Colantha Rube is being mated to the daughters of Denton Colantha Sir Rag Apple. (This mating is of the relationship of nephew to aunt.) The offspring will constitute the first linebred generation. He has already sired one daughter, and

six other cows are pregnant to his service.

The breeding efficiency of the Holstein herd showed marked improvement during the past year. Of the 41 animals which were old enough to calve, 31 dropped 12 male calves, 15 female calves, and 5 dead calves. One cow aborted. Twenty-three of 46 females of breeding age are pregnant. One female calf died, leaving an increment of 14 heifer calves during the year, which is double that of each of the 3 preceding years.

Progress of the Inbreeding - Outbreeding Project

During the past year the Moose O'Fernwood became sterile and was killed at the age of 12 years 10 months. He had one inbred daughter born during the year, making a total of 13 outbred and 2 inbred daughters in the herd. Of the 8 inbred sons and 4 inbred daughters sired by him, 4 sons and 2 daughters died at less than 1 year of age. At the present time his daughters are being bred to a 75 per cent inbred son pending the acquisition of another proved bull of a breeding similar to that of the Moose O'Fernwood. This inbred son now has 10 cows pregnant to his service.

Five inbred and three outbred heifer calves sired by Sophie's Torono 23d were dropped during the year. Three of the inbred heifers and 1 outbred heifer died, leaving a net increase of 2 outbred and 2 inbred heifers. Besides the 3 inbred heifers, 4 of the 6 inbred bulls died at less than 1 year of age. Sophie's Torono 23d now has 19 living daughters, including 2 inbreds.

The unusually high rate of calf mortality among the inbred animals is striking, as 8 of 16 inbred males and 5 of 10 inbred females died at less than 1 year of age. All the fatalities have occurred in the Moose and Torono groups. The 3 inbred Raleigh calves are still healthy. Plans are now being made to determine, if possible, the causes of this high death rate and whether these inbred calves can be raised successfully by different feeding methods than now are being used in the general calf herd.

Tiddledywink's Raleigh, now 11 years old, had 4 out-bred heifers and 1 inbred heifer dropped to his service during the year, raising his total to 12.

Only 3 foundation females of the family-crossing project are still alive, and 2 males and 1 female were born in the two-family groups. One two-family female died, leaving a total of 6 females and 12 males that are the result of crossing individuals of two distinct families. Three four-family females and 1 four-family male born during the year raise the total to 6 four-family females and 2 four-family males. There is also 1 six-family female.

Despite the interference of infertility of two of the herd sires in the Jersey herd during a part of the year, 39 of the 75 females of breeding age dropped 19 male calves, 19 female calves, and 2 dead calves, and 47 females now of breeding age are pregnant.

Official Testing and Photography

In accordance with the plan of giving each female in the breeding project an official production record at 2 years of age and again at maturity, preferably at 5 or six years of age, 25 additional records were completed during the year. An effort is made in this test work to keep the environmental conditions as nearly uniform as possible from year to year. The animals are milked three times a day throughout the year, are kept in box stalls, and receive the same feeds during the entire year. The quantity of feed consumed by each animal is carefully recorded. The production records thus made are considered as the measure of the maximum capacity of the animals under these conditions and are used in the breeding studies as an indication of inheritance for milk and butterfat production.

Of the 25 records completed this year at the dairy experiment station at Beltsville, 10 records were made by Holstein-Friesians and 15 by Jerseys. Six mature Jerseys averaged 11,137 pounds of milk and 597 pounds of butterfat,

4 three-year-olds averaged 7,157 pounds of milk and 395 pounds of butterfat, and 5 two-year-olds averaged 9,717 pounds of milk and 501 pounds of butterfat. The average production of the 15 Jerseys was 9,602 pounds of milk and 511 pounds of butterfat. Five mature Holsteins averaged 17,246 pounds of milk and 614 pounds of butterfat, and 5 two-year-olds averaged 14,511 pounds of milk and 495 pounds of butterfat. The average production of the 10 Holsteins was 15,878 pounds of milk and 555 pounds of butterfat.

Since these projects started, 57 Holstein cows and heifers have completed 81 yearly records averaging 16,477 pounds of milk and 568 pounds of butterfat; and 69 Jersey cows and heifers made 90 yearly records averaging 9,760 pounds of milk and 535 pounds of butterfat. For both groups the average age at which the records were made was 3 years 10 months.

In accordance with the plan of photographing all animals one year of age and over in the breeding herds, 244 photographs were taken during the year.

Proving Bulls

Forty-two Holstein bulls and 30 Jersey bulls are being proved in the vicinity of Beltsville. Four bulls were proved, one of which was sent to the University of Tennessee to be used in a cooperating breeding project. During the past year 12 young bulls were placed and 9 were transferred to other herds. Daughters of two of the 7 bulls in use in cooperative breeding experiments in college herds made world's records for their respective breeds and age classes.

Breeding of Heifers

Difficulty in getting initial conceptions with heifers continues in the breeding herd and is a subject of constant study and observation. The use of sprouted oats in the ration and the omission of silage from the ration are being tried in an effort to improve this condition. Heifers

are bred the first time at the heat following 15 months of age. Twenty-one heifers, all of which were raised in the abortion-free herd, reached breeding age and were bred to bulls known to be fertile. Of the 14 heifers, that are pregnant, 8 conceived at first service, 2 at second service, 2 at third service, 1 at fourth service, and 1 at sixth service, averaging two services per conception for all pregnancies. Of the remaining 7 heifers, 2 have been bred twice, 4 three times, and 1 four times. Some indication of betterment is noted in the 14 conceptions on a two-service average, as the previous herd records show an average of 3.25 services for 105 initial conceptions.

Health of the Herd and Fertility Studies

During the past year 3 females in the negative herd became positive to the agglutination test for abortion disease and were added to the reacting herd. Since May 1926, when most of the reacting animals were moved to new quarters, 31 animals have been taken from the negative herd because their reaction had changed from negative to positive when the agglutination test for abortion disease was applied. Only five of these have changed since October 1926, when a complete separation was made. The positive herd now consists of 76 females, all of breeding age; and the negative herd consists of 142 females, 101 of which are of breeding age. The number of animals of each breed in the positive and negative herds is shown in Table 1.

Table 1. Condition of herd in respect to abortion

Breed	Number in Negative Herd		Number in Positive Herd	Totals
	Breeding Age	Calves		
Grades	24	9	12	45
Holsteins	38	16	18	72
Jerseys	39	16	46	101
Totals	101	41	76	218

The breeding efficiency of the animals in the positive and negative herds may be determined by the following methods: (1) by finding the percentage of animals of breeding age that became pregnant during the year; and (2) by finding the percentage of animals actually bred that became pregnant during the year. According to the first method, the positive herd, with 68 pregnant animals out of a total of 87 of breeding age, has an average breeding efficiency of 78.16 per cent. The negative herd, with 75 pregnant animals out of a total of 100 of breeding age, has an average breeding efficiency of 75 per cent. According to the second method, the positive herd, with 68 pregnant animals out of a total of 78 actually bred, has an average breeding efficiency of 87.17 per cent. The negative herd, with 75 pregnant animals out of a total of 92 actually bred, has an average breeding efficiency of 81.52 per cent.

In the Beltsville herd, the second method of determining breeding efficiency is more desirable than the first method because of the fact that for experimental purposes many animals are intentionally held open from five to eight months after freshening. The number of services per cow vary from the number of services per conception, as shown by Table 2, because of the fact that not all cows bred had conceived at the close of the fiscal year. Table 2 gives additional information for the cows actually bred in the positive and negative herds at Beltsville.

One animal in the negative herd and 5 animals in the positive herd were disposed of because they were considered permanently sterile. In the negative herd, the percentage of females that required more than three services per conception during the past year was slightly greater than in the positive herd. Two Jersey bulls were known to be sterile during part of the year. Table 3 shows the distribution of temporary sterility in the two herds.

Table 2. - Breeding information for animals actually bred

Breed	No. cows in herd	No. Services	<u>Negative Herd</u> No. services per cow	No. concep- tions	No. services per conception	Percentage efficiency
Grades Holsteins Jerseys	21 36 35	77 92 148	3.66 2.55 4.22	13 32 30	5.92 2.87 4.93	61.90 88.88 85.71
Totals Average	92	317	3.44	75	4.22	81.52
Grades Holsteins Jerseys	14 15 49	29 55 184	<u>Positive Herd</u> 2.07 3.66 3.75	12 14 42	2.41 3.92 4.38	85.71 93.33 85.51
Totals Average	78	268	3.43	68	3.94	87.17

Table 3. - Distribution of temporary sterility in positive and negative herds

Negative Herd

Breed	No. cows in herd	More than 3 services per conception			More than 3 services per female not yet pregnant at close of year		
		No. cows	No. heifers	Percentage all animals	No. cows	No. heifers	Percentage all animals
Grades	21	2	1	14.28	3	2	23.80
Holsteins	36	6	2	22.22	1	0	2.77
Jerseys	35	9	2	31.43	2	0	5.70
Total	92	17	5		6	2	
Average				23.91			8.69
Grades	14	1	0	7.14	0	0	0
Holsteins	15	2	0	13.33	3	0	20.00
Jerseys	49	13	0	26.53	6	0	12.24
Total	78	16	0		9	0	
Average				20.51			11.53

Positive Herd

As a means of overcoming temporary sterility in those cases where no pathological conditions could be found, sprouted oats have been fed at the rate of 5 pounds of dry oats a day. During the past year this treatment was effective in the case of six cows and 10 heifers, making a total of 14 cows and 19 heifers effectively treated since sprouted oats feeding was begun. One cow has become pregnant three times after being fed sprouted oats. During the second year she received the oats 71 days before conceiving; during the past year, 77 days. In each of these two years, after having been unsuccessfully bred 5 and 9 times respectively prior to the feeding of sprouted oats, she conceived on the third service after the feeding of oats was started. Before sprouted oats feeding the average number of services for the 14 cows was 7.5, whereas after feeding this number was 2.3.

Eight cows with a relaxation or lack of tone of the genital organs were exercised by walking 7 miles a day for a period of 5 months. Three of these cows became pregnant after the period of exercise. A marked improvement in the tone of the genital organs was noticed in 6 of the cows.

Ovaries from healthy young cows were grafted on 4 cows, and ovaries from healthy pigs were grafted on 7 cows, 4 of these at two different times, making a total of 15 grafts on 11 cows. The pig ovaries were incorporated into the tissues of the host more readily than the cow ovaries. No marked or permanent improvement resulted from the transplanting of ovarian tissue.

The calving efficiency of the two herds is shown by the percentage of living calves born. The 61 pregnancies in the positive herd resulted in 47 living calves, or 77.04 per cent; 8 abortions, or 13.11 per cent; and 6 calves, or 9.83 per cent, born dead. The 52 pregnancies in the negative herd resulted in 42 living calves, or 80.76 per cent; 3 abortions, or 5.76 per cent; 1 mummified fetus, or 1.92 per cent; and 6 calves, or 11.53 per cent, born dead. Table 4 shows the termination of pregnancies in the several breeds of the Beltsville herd.

Table 4. - Termination of pregnancies in the herd

<u>Negative Herd</u>				
Breed	Live calves	Abortions <u>1/</u>	Mummified fetuses	Dead calves
Grades	9	0	1	1
Holsteins	18	2	0	4
Jerseys	15	1	0	1
Totals	42	3	1	6
<u>Positive Herd</u>				
Grades	8	0	0	2
Holsteins	10	2	0	3
Jerseys	29	6	0	1
Totals	47	8	0	6

1/ The three abortions occurring in the clean herd were the result of unknown causes. Examinations of the fetuses by the Bureau of Animal Industry did not show B abortus or any other infection that might have been responsible for abortion, nor did the aborting cows react to the agglutination test for abortion disease either before or after the abortion.

All animals are examined after calving and again before breeding to determine whether any condition exists that might prevent conception. They are also examined for pregnancy sixty days after service. A total of 187 animals were examined 706 times. Table 5 shows the abnormal condition of the genital organs of cows in the herd for 1928. A comparison of these conditions for 1927 and 1928 is shown in Table 6.

Out of a total of 291 animals in the Beltsville herd during the past year 33 deaths occurred, the causes of which are as follows:

Digestive disturbances 1/.....	14
Septicemia	1
Peritonitis	1
Affected lungs	2
Poisoning	1
Injury	1
Congenital anomaly	1
Overstimulation	1
Undetermined	2
Slaughtered - no longer of value 2/	9

Fertility Experiments With Bulls

An attempt was made to examine the semen of each herd sire once a month and when required in the progress of an experiment. An estimate of the activity and number of spermatozoa and studies of the morphology and of the methods for determining more accurately the physiological activities of spermatozoa were made of 165 samples of semen. The studies to determine the effect of the different nutritional regimes, as previously reported, have been continued.

1/ Six of these deaths were due to foreign bodies and 5 to digestive troubles in calves
2/ Organs of these cows were used for anatomical studies during the year.

Table 5. - Abnormal condition of genital organs of cows in the herd, 1928

Breed	<u>Negative Herd</u>			Inflammation of cervix
	Corpus Luteum (interfering with estrum)	Ovarian cyts	Inflamma- tion of uterus	
	Number	Number	Number	Number
Grades	5	0	3	0
Holsteins	1	1	0	1
Jerseys	3	0	2	0
Totals	9	1	5	1
	<u>Positive Herd</u>			
Grades	4	0	0	0
Holsteins	3	1	4	2
Jerseys	2	1	7	4
Totals	9	2	11	6

Table 6. - Abnormal condition of genital organs of cows at Beltsville (1927 and 1928)

	<u>Negative Herd</u>			<u>Positive Herd</u>		
	Number of animals			Number of animals		
	1927	1928	Total	1927	1928	Total
Corpus luteum (interfering with estrum)	18	9	27	38	9	47
Ovarian cysts	3	1	4	9	2	11
Inflammation of uterus	0	5	5	9	11	20
Inflammation of cervix	4	1	5	9	6	15
Persistent ovarian cysts (resisting all treatment)	1	0	1	2	0	2

In an attempt to prolong the usefulness of four bulls showing senility and one showing aspermia, testicular tissue was grafted on the affected animals. The testicles used were from a young healthy bull and from young healthy pigs. The results were as follows:

One bull grafted twice with bovine testicle and once with pig testicle showed no improvement in activity or numbers of spermatozoa. One bull grafted twice with bovine testicle showed no improvement in activity or numbers of spermatozoa. One bull grafted once with pig testicle showed slight improvement in activity of spermatozoa for a short time. One bull grafted once with pig testicle showed marked improvement in activity of spermatozoa. This improvement has been maintained. One grafting of pig testicle on a bull affected with aspermia resulted in the appearance of many heads of spermatozoa and a few apparently normal active ones. Two months later no spermatozoa were found. In all cases a marked physical change was noted in improved appetite, gain in weight, limbering of joints and muscles, and greater activity of the animal.

A Study Of The Relation Of The Conformation and Anatomy Of The Dairy Cow To Her Milk and Butterfat Producing Capacity

The slaughtering of cows of known producing ability for the purpose of determining the relationships between the external form and internal anatomy and between internal anatomy and producing capacity has been continued. Four experiment stations, North Carolina, South Carolina, Alabama, and Oklahoma, have been added to the list of co-operators. Ante-mortem and post-mortem reports on 51 cows having production records were obtained during the year. Eleven of these reports have been prepared at Beltsville, Md., 12 at Pennsylvania State College, 8 at Cornell University, 5 at the University of Missouri, 7 at Clemson College, S. C., and a total of 8 at the State experiment stations of North Carolina, Oklahoma, Utah, Iowa, and Geneva, New York. Ante-mortem and post-mortem reports of 187 cows having production records are now on file. Of this number, 60 have been prepared at Beltsville, Md., 48 at Pennsylvania State College, 40 at Cornell University, 9 at the University

of Missouri, 7 at Clemson State College, S. C., and 5 or less from each of 8 other stations. Instruments for measuring conformation have been distributed to the newly added cooperating stations, and a set of special calipers for measuring the carcasses of cows included in this test has been made for distribution to all cooperating stations.

Mammary Gland Studies

Studies to determine the capacities of the secretory system of udders have been continued. The results obtained during the past year from a study of 11 udders show, as did experiments previously reported, that the capacity of the secretory system is greatly in excess of what it has commonly been thought to be. Table 7 shows the capacity of the udders of the 31 animals studied since this investigation was begun.

Table 7. - Quantity of fluid and milk equivalents accommodated by the udders of 31 animals.

Type of Animal	Number	Quantity fluid	Milk Equivalent
		c.c.	Lbs.
Lactating cows	14	19,193	43.60 ¹ / ₂
Nonlactating cows	8	12,236	27.80 ¹ / ₂
Heifers and young cows never pregnant	6	4,190	9.52 ¹ / ₂
Beef cow	1	3,620	8.22
Calf at 2 mo. 15 days	1	184	.42
Calf at 3 mo. 19 days	1	240	.55

¹/₂ Average.

Post-mortem milking tests have been conducted on 3 cows during the past year. One cow yielded 15.35 pounds, or 62.07 per cent, another yielded 15.45 pounds, or 72.71 per cent, and the third yielded 15.20 pounds, or 87.31 per cent of the average quantity obtained at corresponding

milkings before death. The average yield of these three cows was 15.33 pounds, or 74.03 per cent of the average quantity obtained at corresponding milkings before death. Seven post-mortem milking tests have been previously made. In the first four tests, where the conditions of killing the cows were not entirely controlled and where the amputated udders were not maintained at body temperature, the average quantity of milk recovered was 9.22 pounds, or 61.10 per cent of the quantity obtained from the same udders at corresponding milkings before death. The other three udders were handled under more carefully controlled conditions and yielded 13.3 pounds of milk after amputation, which is equivalent to 78.22 per cent of the quantity obtained before death. The six udders studied under controlled conditions yielded 14.33 pounds, or 76.37 per cent of the quantity obtained at corresponding milkings before death. From the studies which have been made it is becoming more and more evident that milk secretion is largely a continuous process and that a relatively large proportion of the milk obtained from the udder at any milking is in the udder before the milking process is commenced.

Chemical analyses have been completed of the milk obtained from all the amputated udders except the last two. In these analyses the milk obtained after death has been about half as high in butterfat as that of the milk obtained from the same cows before death. During the year an attempt has been made to determine the cause of this. A number of methods employed have resulted in only limited success in recovering a significant quantity of butterfat from the amputated udders after the completion of post-mortem milking.

In preparing material for the study of udder structure the udders of two calves were dissected at the ages of 2 months 15 days and 3 months 19 days; the udders of two cows were amputated 2 and 4 days respectively after calving; and an udder with a blind quarter was sectioned. Extreme contrasts in the structure of different udders have been

noted throughout the study.

An apparatus for determining such physical properties as sponginess, porosity, and fluid-carrying capacity per unit of volume of tissue from different udders has been designed.

The histological study of sectioned udders has been continued during the year. This phase of the work has been carried on by the pathological division, Bureau of Animal Industry.

Comparison of Conformation and Anatomy of Dairy and Beef Animals

The study of the conformation, anatomy, and skeletal structure of Sophie 19th of Hood Farm, a purebred Jersey cow, and of Blackbird of Dallas, a purebred Aberdeen Angus cow, is now completed. Differences in the outer conformation were extreme, but differences in the internal anatomy were slight. Differences in the skeletal structure were not extreme. The most outstanding difference found was in the amount of mammary tissue in the udders of the two cows. The udder of Sophie 19th of Hood Farm was composed of gland tissue throughout its entire area, whereas that of Blackbird of Dallas contained only a very small area of secretory tissue. During the year the external conformation, internal anatomy, and skeletal structure of a purebred Jersey bull have been similarly studied. This skeleton has been mounted. The skeleton of a dairy calf and parts of the skeleton of a dairy cow are now being prepared for additional studies of skeletal structure. An experiment has been commenced at Jeanerette, Louisiana, in cooperation with the animal husbandry division, Bureau of Animal Industry, for the purpose of determining the extent to which the udders of dairy cows differ from those of beef cows kept under the same conditions.

Growth Studies Of Heifers

Measuring the Gains

Investigations on the growth of heifers have been continued. These investigations show that a maximum rate of increase is attained early in life, after which the rate decreases until maturity is reached. Occasional temporary accelerations of growth were observed, sometimes lasting several months; but these were followed by retardations so that the normal characteristic of diminishing gains for the greater part of the growth period was preserved. Table 8 shows the average weights of Jersey and Holstein heifers at Beltsville, for 6-month periods. Assuming that there is no hereditary check on growth, the weights given in this table may be regarded as a reliable index of weights that can be attained by Jersey and Holstein heifers grown under conditions of feed and management similar to those provided at Beltsville. The table also shows that during the first year of life almost equal gains were made in each 6-month period. After the first year semiannual gains decreased, the rate of decrease becoming more rapid after the age of 2 years.

Of special importance is the fact that at 6 years of age the Holsteins were still increasing in weight. There is reason to believe that the gains made at this age indicated actual growth and not merely a deposition of fat accompanying maturity. Just how long growth of a cow can continue is a matter demanding further attention. The problem of determining the relationship between maturity of growth and maximum milk-secreting ability also remains to be solved. The present data indicate probably that under the environmental conditions at Beltsville, the Holsteins continue to grow beyond the age of 6 years, whereas Jerseys at that age have attained mature growth.

Prenatal Development

A method of determining prenatal growth is especially desirable because growth in its entirety extends from time of conception to time of maturity. Since prenatal

growth covers about three-fifths of the total period prior to the occurrence of maximum gain, the characteristics of the growth curve prior to birth must be regarded as of the utmost importance. During the past year work has been started on the determination of normal growth of the fetus and the relative increase in the amount of the amniotic fluid and placental membranes during the successive stages of gestation. Data obtained up to the present time are given in Table 9. In the first and fourth cases shown in the table the fetus was weighed after the death of the cow. In the other cases the fetus was weighed after an abortion. The evidence available at this time does not provide an adequate basis for formulating normal intrauterine weight curves. It is, however, a beginning in the study of an important phase of growth that has hitherto received scant attention.

Relationship Between Birth Weight and Subsequent Weights

A study to determine the relationship between birth weight and subsequent weights of the animal shows that the weight at birth does not necessarily indicate the size that the animal will attain later in life. Data have been obtained for 27 Holstein heifers reared at Beltsville to the age of two years. The coefficients of correlation expressing the relationships between birth weight and the weights attained at 6 months, 1 year, and 2 years are as follows: 0.195 ± 0.125 , 0.053 ± 0.125 , and 0.314 ± 0.117 . In no case is a significant correlation established.

Variability of Growth

During the past year, weights of heifers in a private herd of Guernseys (Herd B) have been obtained as a basis for determining certain characteristics of variability in weight. Similar data from a private Guernsey herd (Herd A) were obtained last year. The following shows a comparison of the variability of growth of the animals in these two herds:

Birth, 64.9, 62.8 pounds; 6 months, 316.7, 336.3 pounds; 12 months, 537.4, 620.1 pounds; 18 months, 686.8, 778.5 pounds; 24 months, 809.8, 919.0 pounds. A comparison of the

Table 8. - Average semiannual weights of Jersey and Holstein heifers, Beltsville, Maryland

Age months	Jerseys			Holsteins		
	Number	Weight	Gain	Number	Weight	Gain
		Lbs.	Lbs.		Lbs.	Lbs.
0	35	55		27	97	
6	35	258	203	27	360	263
12	35	464	206	27	627	267
18	35	604	140	27	845	218
24	35	739	139	27	1056	211
30	35	827	88	28	1127	71
36	39	874	47	27	1211	84
42	24	944	70	24	1260	49
48	21	906	-33	18	1228	-32
54	13	931	25	17	1353	125
60	9	928	-3	14	1279	-74
66	9	945	17	9	1349	70
72	3	951	6	7	1393	44

Table 9. - Prenatal Weights - Beltsville, Maryland

Breed	Days from service	Fetus	Placenta	Amniotic fluid
	Number	pounds	pounds	pounds
Jersey	58	0.030	0.19	0.83
Jersey	90	0.310	0.31	2.19
Jersey	122	1.300		
Jersey	233	29.000		
Holstein	52	0.003	0.10	
Holstein	225	28.750		27.25

monthly weights shows that beginning at the age of 1 month and continuing to the age of 2 years, the weights of the heifers in Herd B exceeded those of Herd A.

The heifers in Herd A received whole milk from birth until the age of 3 months, when it was discontinued. In Herd B, after 3 days of age one half of the ration consisted of skim milk and the other half of whole milk. At 4 months of age whole milk was dropped from the ration and a heavy feeding of skim milk was given.

For the greater part of the two-year period the heifers in Herd B exhibited greater growth uniformity than did Herd A, as the coefficients of variation in Table 10 indicate. A few of the animals in Herd A attained excessive size for the herd, others were relatively small, whereas a smaller percentage of the population approached the average size for the herd each month than was the case in Herd B. The heifers in Herd B were bred at 13 months of age and immediately variability increased. The heifers in Herd A were bred at 15 months, but apparently gestation was not accompanied by greater variability.

Pasture Versus No Pasture, Beltsville, Maryland

Whether or not heifers on pasture attain greater weights than do those not on pasture has been considered statistically for Holstein heifers at Beltsville. The differences in the average weights of the pasture groups and non-pasture groups are given in Table 11. When these differences are considered in connection with their probable errors, the excess is large enough to be significant in only the 24-month group. This excess, favorable to the non-pasture group, should be accepted with reservation, however, for at two years of age gestation is common to animals in the herd and has possibly influenced this particular result. In general, it can be stated that calves that have had access to pasture at Beltsville have not attained significantly greater weights than those that have not.

Table 10. - Coefficients of variation of weights of heifers
in two Guernsey herds.

Age - months	Herd A 21-51 heifers	Herd B 23-34 heifers
0	15.6	15.0
1	19.1	15.0
2	20.0	15.1
3	20.4	13.7
4	22.4	12.4
5	18.4	11.7
6	17.1	11.4
7	15.3	10.6
8	15.5	10.1
9	16.2	10.2
10	15.1	9.6
11	15.9	12.6
12	16.8	11.7
13		11.8
14		14.4
15	16.5	14.7
16		15.4
17		14.7
18	10.4	13.4
19		17.5
20		19.0
21	12.4	17.9
22		16.1
23		18.6
24	11.7	19.3

Field Stations

At the Huntley, Mont. Station an experiment has been conducted in which ten cows were fed for one year each of the following rations: (1) roughage alone, consisting of corn silage, roots, alfalfa hay, and irrigated pasture; (2) the same roughages and a limited grain ration of one pound of grain mixture to each six pounds of milk produced; and (3) the same roughages and a full grain ration of one pound of grain to each three pounds of milk produced. When the cows were fed roughage alone but no pasture, they failed, by a small margin, to consume sufficient nutrients to meet their requirements for milk production; and they lost, on the average, 23 pounds of weight per cow. On the limited grain ration, the cows gained 90 pounds on the average; and all but one cow consumed sufficient nutrients to meet their requirements, the average excess of nutrients consumed being 2.4 per cent. On the full grain ration, the larger gains in weight were made; and the consumption of nutrients on the average was 29 per cent in excess of requirements. When the values of the products and the feeds were calculated at the prices at Huntley, the limited grain ration proved most profitable but was closely followed by the roughage ration.

Thus far 42 cows on the full grain ration, 13 cows on the limited grain ration, and 15 cows on the roughage ration have completed the semiofficial records of milk and butterfat production. The results are shown in Table 12.

Twenty-three cows weighing, on the average, 1,091 pounds at the beginning of the experiment were maintained for 16 weeks on irrigated mixed-grass pasture alone and at the end of this period weighed, on an average, 1,148 pounds. During the first week they produced an average of 206 pounds of milk and at the end of the sixteenth week they produced 137 pounds. Taking into consideration the four months' advance in lactation and the advance in period of gestation, this decline in milk production agrees quite closely with the calculated decline. The production held up well until the twelfth week but dropped quite rapidly between the twelfth and sixteenth weeks.

Table 11. - Differences in excess of weight between Holstein heifers when given pasture and Holstein heifers not given pasture, Beltsville, Maryland

Age-months	Number on Pasture	Excess in favor of heifers on pasture	Number not receiving pasture	Excess in favor of heifers not receiving pasture
		Pounds		Pounds
14	3		24	1.92 ± 15.05
15	4		23	16.79 ± 15.19
16	5		22	38.95 ± 13.12
17	4		23	12.77 ± 18.58
18	7	14.38 ± 19.4	20	
19	7	31.16 ± 17.92	20	
20	9	22.78 ± 15.99	18	
21	9	10.56 ± 20.40	18	
22	11		16	25.40 ± 17.30
23	13		14	51.41 ± 17.71
24	9		18	83.34 ± 17.41

Table 12. - Production records of cows on three different planes of feeding

No. cows	Age	Ration	Milk Production	Butterfat production	
				Actual	Calculated to maturity
	Y - M		Lbs.	Lbs.	Lbs.
42	3 - 8	Full grain	14,868.1	519.08	613.4
13	6 - 1	Limited grain	16,200.5	566.86	588.9
15	6 - 5	Roughage	13,032.8	452.88	465.3

At Iberia, La., owing to the Mississippi River flood in May, 1927, it was necessary to remove the cows hurriedly from the experiment farm to a farm that was reported to be free from cattle ticks. Later it was found that cattle infested with ticks had been in the pasture. The cattle of the Bureau of Dairy Industry became infested, contracted the fever, and nine died. Prompt treatment saved the other animals that had the disease. One of the serious results of the illness of the cattle has been sterility; considerable difficulty has been experienced in getting the herd to breed. The necessity of removing the dairy cattle from the farm for a time, the illness of most of the milking animals, and the injury to the crops by the flood, have hindered the progress of the experimental work during the past year. F. S. Fletcher, who had charge of the dairy herd since June, 1925, resigned to go into commercial work, and S. L. Cathcart was appointed April, 1928, to succeed him.

At Woodward, Okla., during the past year, a trench silo was used for the first time and the silage kept well. C. J. Stauber, who has been in charge of the dairy work since June, 1921, has been transferred to Beltsville, Md. Station and A. G. Van Horn has been appointed to fill the position.

At Ardmore, S. D., experiments are under way to compare the value for milk production of given areas of pastures of various kinds when grazed, when the grass is cut and fed green, when the grass is allowed to mature and is fed as hay, and when it is ensiled and fed as silage. These experiments at Ardmore and at the other field stations will serve as a check on the yield of nutrients from pastures by these different methods of handling, and at different stages of maturity, in the various localities.

In some preliminary experiments during the summer of 1927, it was found that a few of the Holstein-Friesian cows were able to consume as much as 110 pounds of Sudan grass per day. This agrees remarkably well with the total quantity of corn silage and alfalfa hay consumed by some of the cows on the roughage ration fed at Huntley, Mont., when the alfalfa hay consumed is calculated to its green weight.

At Mandan, N. D., buildings have been completed for for the new dairy station. A dairy barn of a new type contains open pens for the cows in units of six head each and mangers and stanchions along one side next to the feeding alley. This arrangement will permit the cows to be stanchioned while being fed; at other times they will run loose. They will be milked in a room containing stalls for six cows. A horse barn, an implement shed, and a residence for the man in charge have also been completed. Crops have been planted this spring. A herd of purebred Holstein-Friesians will be shipped to Mandan during the summer from the Huntley Station and a few animals from the Utah Experiment Station. A. L. Watt has been appointed to take charge of the work at the Mandan Station.

MARKET-MILK INVESTIGATIONS.

Ernest Kelly, in Charge.

Dairy Sanitation

The intensive study of the bacteriological condition of milk as it passes through city milk plants has been continued. The object of this work is to determine the causes and to work out remedies for high bacterial counts which are the result of improper milk-plant procedure. Bacterial counts of the milk are taken from the time it enters the plant until it is ready for delivery to the consumer. In this way a complete bacteriological history of the milk during preparation for market is obtained. These studies are being carried on in all parts of the country so as to cover differing conditions of climate, geography, and methods of handling. Up to the end of this fiscal year studies in 97 milk plants have been completed, each study including a five-day run at each plant in order to eliminate any abnormal daily variations. Of these 97 plants, 61 were completed during the present fiscal year in the following States: Maryland, Virginia, New Jersey, Ohio, Kentucky, Minnesota, Wisconsin, New York, Alabama, Tennessee, and the District of Columbia. Further work will include plants in the Middle West and far West. More than 300 runs on different days and more than 2,000 bacteriological examinations have been made. Data have been compiled and tabulated for 57 plants, varying in capacity from 100 to 30,000 gallons and differing both as to equipment and methods. This group of plants had the following average bacterial counts:

Bacteria per cc.

Raw milk	969,700
Pasteurized milk from pasteurizer after holding	28,400

Pasteurized milk from bottom of cooler	34,100
Bottle of pasteurized milk from filler	39,600
Pasteurized bottled milk after 24 hours storage	45,100

A study of these figures shows a gradual and fairly uniform increase in bacterial count at each subsequent step from the time of pasteurization until after the storage period.

Studies of temperatures in cold-storage rooms have also been continued. It has been found that some cold-storage rooms vary as much as 30° F. in temperature during a 24-hour period, and also that different parts of the same room vary as much as 15° F. in temperature. What are known as "pockets" or "dead spaces" have been noted. The temperatures of two cold-storage rooms equipped with fans have been studied, and results show that the temperature was more nearly equalized by the use of fans than when fans were not used.

As a result of these studies various factors which will aid in reducing the bacterial counts of both raw and pasteurized milk have been pointed out in individual plants.

At four plants studies were made to locate the cause of "pin-point" contamination, an especially troublesome item of milk-plant sanitation.

During the year 420 municipal and State milk ordinances have been obtained and digested. The principal points of these ordinances have been entered on special cards so that quick tabulation can be effected. The bureau has continued to advise with city and State health departments, agricultural colleges, and State dairy and agricultural commissions regarding standardized methods of inspection and sane and effective legislation for the sanitary control of milk supplies.

During the summer and autumn of 1927 fly-control work was continued at the Beltsville Farm. From May 11 to November 12, ten traps caught a total of 57.5 gallons of flies, or 8 per cent less than in 1926. Spraying of cattle and barns was continued with the pyrethrum-kerosene mixture, which proved very effective in killing horn flies and house and stable flies where there was not too free a circulation of air. The spray cost 29.57 cents per gallon, and 213 gallons were used during the season. A high-pressure portable sprayer was planned and built during the summer at a cost of \$36.04. This sprayer carries a pressure of more than 100 pounds and requires about 100 strokes to pump it to 90 pounds pressure. Piles of manure were treated with borax solution and with fuel distillate. Neither gave good results as the whole pile was not penetrated, so that the larvae were able to crawl beyond the point of penetration of the liquid. However, treating the ground under the manure with the fuel distillate gave very good results. It was estimated that this killed more than 90 per cent of the larvae, and it seemed to prevent them from entering the ground. Treatment was made at the rate of 1 gallon distillate to 20 square feet.

The bureau has continued its supervision over milk delivered in various Government buildings. Four dairies hold permits from this bureau to deliver milk in the buildings of the Treasury, Commerce, and Agricultural Departments. The quality of the milk has been exceptionally high during the year.

Sanitary inspections and bacterial counts at the Beltsville farm have been maintained. The conditions have been remarkably good, especially in consideration of the fact that this is an experimental farm.

The bureau has continued its sanitary work in an advisory capacity at the United States Naval Academy Dairy. The average score for this dairy for the past year was 97.4, and the average bacterial count for the entire year was 2,711 per cc. This puts the milk that is being furnished to the midshipmen at the Naval Academy far within the bacterial limits set for certified milk.

Milk Plant Management

Very satisfactory progress has been made in the studies of milk-bottle breakage. These studies are to determine the effect of plant arrangement, types of equipment, and methods of operation on the amount of bottle breakage in milk plants. This has been one of the most popular projects ever undertaken by the bureau, and excellent cooperation has been received from milk dealers. During the year thorough surveys of several days each have been made in 65 milk plants in Chicago, Milwaukee, Philadelphia (including Camden, N. J.), Washington, and Greater New York and nearby cities. If abnormal conditions seemed to exist at the time of the investigation a recheck was made. In these plants the quantity of broken glass per thousand bottles filled ranged from 6-1/2 to 26 pounds. Not only have these total losses been studied, but the losses have been allocated to the various points of breakage, and a special study has been made of conditions causing high breakage and remedies suggested. This work has shown that it is perfectly feasible to reduce very greatly the excessive breakage of bottles in milk plants. Some of the interesting factors indicated so far in this work are as follows:

1. The size of the plant has very little effect on the amount of breakage.
2. Where bottles are sent upstairs to be washed, the breakage is greater than where they are washed on the ground floor or in the basement, provided the washer delivers the bottles on the ground floor.
3. There is a direct relation between the number of transfers of the bottles from floor to floor and the amount of breakage.
4. The breakage is greater where trucks are used to transfer the bottles to the washer than where conveyors are used, and the breakage is less where the bottles are checked in at a point close to the washer than where conveyors are used and some of the bottles are stacked.
5. The breakage is greater with the indirect system of washing and filling than with the direct system. This seems to be due to less handling and a better control of

temperature in the case of the indirect system.

6. In general there are not proportionately more quart bottles broken than smaller-size bottles.

7. Most of the chipping of bottles occurs on the routes. At one plant the proportion of wholesale chipped to retail chipped bottles was in the ratio of 4 to 1 for a period of 8 days.

8. Whether bottles come to the washers by gravity or by automatically controlled conveyors has an important bearing on the bottle breakage, it being considerably less with the latter system.

9. Lack of temperature control at the washer results in too abrupt changes at certain points and causes much extra breakage. Some of the bottles are not broken until they reach the filler, however, as they may be "fatigued" in the washer and broken by the pressure at the filler.

10. Types of washers where bottles are stacked for cooling require extra handling of the bottles and result in considerable breakage. A hot bottle is more apt to break when jarred or struck than a cold bottle.

Other causes of bottle breakage were found to be as follows: Poor condition of cases, allowing bottles to strike together; plant running beyond normal capacity, resulting in employees having neither the time nor space to handle or store the bottles carefully; stacking bottles 8 and 9 cases high in the ice box; steep escalators moving cases of empty bottles to upper floors, causing cases to stick, jam, and buckle; sharp curve immediately behind the escalator, increasing the tendency for cases to stick and buckle; conveyors so low that men drop and slam cases on them; conveyors so far from stacks that men must toss cases on the conveyors; worn and uneven rubber pads at the discharge end of the washer, causing the bottles to topple over and crack; spiral conveyors of small diameter, causing cases to jam and stick frequently.

In addition to the bottle-breakage work, labor studies have been made in ten milk plants which show the man hours

required for certain labor operations about the plant, such as bottling and bottle washing.

Market Milk And Cream

Flavor and Odor.

In the spring of 1928 this bureau was called upon to help solve the problem of off flavor in bottled milk at one of the plants in Washington, D. C. The milk developed a cappy or cardboard flavor after pasteurization and storage over night. An intensive investigation was started. Samples were taken of all off-flavored raw milk coming in to the plant. Laboratory pasteurization of these samples showed that the peculiar flavor noted was not due to the raw milk. Samples also were taken in the plant of all milk after it had passed through each piece of apparatus and the trouble was finally attributed to one section of the milk cooler. This was a two-way cooler, the top portion of which was a water regenerative coil while the bottom section was cooled by direct expansion. The water section was made of nickel, whereas the direct expansion section was made of German silver. Numerous samples failed to show any off flavor after the milk had passed over the nickel section, but the characteristic objectionable flavor was found after the milk had passed over the German silver portion of the cooler. The flavor was not uniformly distributed throughout the milk, and it was found that the procedure of the plant had a good deal to do with this. When the milk was at a relatively high temperature on reaching the lower section of the cooler, the flavor was much more pronounced; but when the milk was around 60° F. or lower on reaching the lower section of the cooler the flavor did not develop. Laboratory experiments with copper, zinc, monel metal, and nickel separately and in combinations in milk showed that the characteristic objectionable flavor developed whenever copper was present as one of the metals either in the pure state or as an alloy. As German silver is an alloy containing a high percentage of copper, it was very apparent that this was the cause of the trouble.

Viscosity of Cream

This project has been continued along two main lines: First, to determine the effect of various methods of cooling on the viscosity of the cream; and second, to determine the effect of various methods of handling the milk before separation on the viscosity of the resultant cream.

In cooling raw cream with a butterfat content of either 20 or 30 per cent, slow cooling from the separation temperature of 26° C. to 5° C. gave a slightly higher viscosity than rapid cooling between these two temperatures. The increase in viscosity due to slow cooling was slightly greater for the richer cream. In the case of pasteurized cream, slow cooling from the pasteurization temperature of 62.5° C. to a temperature of 5° C. gave a greater increase in viscosity than did rapid cooling. Furthermore, the increase in viscosity was more marked with the pasteurized cream than with the raw cream. Slow cooling of pasteurized cream from 62.5° C. to a temperature of 30° C. followed by rapid cooling from 30° C. to a temperature of 5° C. gave a greater viscosity than rapid cooling from 62.5° C. to a temperature of 5° C. However, this increased viscosity was not so great as when the pasteurized cream was cooled slowly over the entire range from 62.5° C. to 5° C. Slow cooling from 62.5° C. to a temperature of 45° C. followed immediately by rapid cooling from 45° C. to a temperature of 5° C. gave a slightly better viscosity than rapid cooling over the entire temperature range, but the viscosity was not so great as when the cream was slowly cooled to 30° C. and then rapidly cooled from 30° C. to a temperature of 5° C. Slow cooling of pasteurized cream followed by aging for 24 hours gave a greater increase in viscosity than did rapid cooling with the same subsequent aging. Furthermore, the aging of cream for 24 hours after pasteurization resulted in a higher viscosity than when the cream was not aged. Cooling cream after separation and before pasteurization had practically no effect on the viscosity of the pasteurized cream.

The viscosity of cream is influenced by the method of handling the milk prior to separation. Cream containing 30 per cent butterfat skimmed from milk which had been stored for 3 hours at 4° C. before separation had at 5° C. a viscosity more than 14 per cent greater than cream skimmed from the same milk stored for 3 hours at 8° C. A storage time of 3 hours, as compared with 12 hours, resulted in a greater increase in viscosity of cream from milk stored at a low temperature than from milk stored at 18° C. The viscosity of the cream at 5° C. skimmed from milk stored at 4° C. for 12 hours, however, was 4.8 per cent greater than the viscosity of the cream from milk stored at the same temperature for only 3 hours. The increase in viscosity of cream due to storage of milk at a low temperature before separation is not entirely lost by the pasteurization of the cream.

Although this phase of the work has not been completed, sufficient progress has been made to indicate that the viscosity of cream from pasteurized milk is dependent upon the handling of the milk after pasteurization. If the milk is separated directly from the pasteurizer without cooling, the viscosity of the cream is lower than for cream pasteurized after separation. If the pasteurized milk is slowly cooled in the vat to separating temperature (26° C.) the viscosity of the cream is greater than that of cream pasteurized after separation; whereas if the milk after pasteurizing is rapidly cooled to separating temperature by means of a surface cooler the viscosity is lower than for cream pasteurized after separation.

Throughout this work, in order to determine some of the reasons that a change in the method of handling causes a change in the viscosity of cream, a microscopic study of the cream has been made. This study has shown that the viscosity is directly proportional to the degree of clumping of the fat globules; or in other words, any factor affecting the clumping of fat globules affects the viscosity of cream.

Slowly cooled cream had a higher viscosity than rapidly cooled cream. It has been shown that the clumping of fat globules starts at a temperature above the melting point of fat and continues to a temperature of about 7° C.

It seems reasonable to suppose, therefore, that if the temperature of the cream passes slowly through the temperature range which is favorable to clumping, more clumping of fat globules will take place. On the other hand, if the cream is cooled rapidly through and below this temperature range, not only does it allow but little time for the clumping of fat globules, but the rapid cooling to a low temperature congeals the fat globules so that no further clumping takes place. This is believed to account for the higher viscosity with slow cooling. Therefore, in the case of gravity separation, during the cream rising the clumping of fat globules is more complete than in the case of centrifugal separation. Likewise, when the milk is stored at low temperatures it undoubtedly passes through the range of temperature favorable for maximum clumping. Furthermore, the longer storage period gives time for a more complete clumping of fat globules.

DAIRY INTRODUCTION

J. H. McClain, In Charge

Dairy-Herd Improvement

Dairy-Herd-Improvement-Association Investigations

From January 1, 1927 to January 1, 1928 the number of dairy-herd-improvement associations in this country increased from 837 to 947, a gain of 13 per cent. The number of cows on test increased from 362,014 to 414,891, a gain of 14.6 per cent.

During the year studies based on approximately 200,000 yearly individual cow records from 684 dairy-herd-improvement associations have been made. These records were obtained through a cooperative agreement with 43 States. Copies of herd and association summaries, together with copies of annual tabulations of all records received from each State on the following topics, were sent to each cooperating State: Relation of milk and butterfat production to income over cost of feed and other factors; influence of season and month of freshening on milk and butterfat production and income over cost of feed; relation between cost of grain and other factors; and comparison of purebred and grade dairy cows.

A very important phase of these record studies has been the proving of 215 bulls in dairy-herd-improvement associations by comparing the records of five or more of their daughters with the records of the dams of the daughters. About 1,500 bulls have been partly proved by comparing the records of from one to four daughters with the records of the dams of the daughters. This study indicates that in dairy-herd-improvement associations one-third of the bulls decreased production of their daughters, one-third increased production slightly, and one-third increased the production by a comparatively large margin.

A study of nearly 140,000 yearly individual cow records has been in progress to ascertain the relation of size of cow within the breed to production and income over cost of feed. Present results indicate that within the breed the big cow is the largest producer of milk and butterfat and has the highest income over cost of feed.

A comparison of the production records of more than 100,000 yearly individual records of purebred and grade cows showed that the purebreds produced 10.6 per cent more milk, 6.7 per cent more butterfat, and returned 9.7 per cent more income over feed cost than did the grades.

A comparative study has been made of dairy-herd-improvement associations by years as to average production, feed cost, and income over cost of feed. The results of this study are shown in Table 13.

Table 13. - Comparison of dairy-herd-improvement associations by years, as to average production, feed cost, and income over cost of feed.

Year	Number ass'ns	Number cow years	Average production		Average cost of feed	Average income over cost of feed
			Milk	Butterfat		
			Pounds	Pounds	Dolls.	Dolls.
Prior to						
1920	120	37,362	5,989	247	53	59
1924	129	32,091	7,092	279	68	94
1925	380	98,704	7,189	284	67	89
1926	476	127,617	7,316	289	69	101
1927	532	142,084	7,410	293	73	111

Dairy-Herd-Improvement Association Methods

In cooperation with the State dairy extension specialists and the dairy-herd-improvement-association committee of the American Dairy Science Association, studies of methods of organization, publicity, and standardization of methods

in dairy-herd-improvement associations have been continued. Investigation of so-called short-cut testing methods has also been continued. A new undertaking has been the placing of a representative in Alabama to introduce the every-other-month plan of testing, which investigational work by the bureau has shown to be practical. Since March, 1928, when the work was started, three associations containing 74 members and 3,570 cows have been organized. In 24 States either State or regional conferences of testers have been attended or investigational studies have been made by a representative of the bureau.

Purebred-Sire Introduction

The purebred-sire-introduction project comprises the organization and conduct of scrub-bull-eradication campaigns, organization of bull associations, and the study and introduction of methods for preserving the lives of bulls which have been proved through dairy-herd-improvement association records. Studies thus far have shown that a large majority of bulls used in dairy-herd-improvement associations are disposed of before their value can be ascertained.

During the year assistance in conducting eight scrub-bull-eradication campaigns in four States has been rendered State extension specialists. As a result of this work 150 purebred dairy bulls were placed. In one county alone, 200 scrub and grade bulls were eradicated.

In one State assistance was given in organizing three bull associations owning 15 bulls. The total number of associations in the United States on January 1, 1928, was 235. These associations comprised 33,507 cows and 992 bulls. During the year some phase of purebred-sire-introduction work has been carried on in 23 States.

Dairy Manufacturing

Butter and Creamery Work

Defects in the body of butter resulting from the use of feeds, such as cottonseed meal, causing a lower price for the product, are being studied. Modifications of certain creamery methods have been found to overcome these defects to some extent.

A study has been conducted of the shrinkage in weight of butter in one-pound prints during 6 months storage at 0°F. The results showed a loss of slightly less than one-eighth ounce per pound when butter was made under normal conditions and the moisture well incorporated.

Final results have been obtained from the study made to determine the maximum percentage of acid that cream may contain when churned without producing a deleterious effect on the quality of the butter during storage. These results show that during eight months' storage at 0°F., butter made from cream containing 0.22 to 0.31 per cent acid deteriorates but little more than butter from cream containing only 0.15 per cent acid. Butter made from cream containing 0.35 per cent acid deteriorated somewhat more, whereas the deterioration of butter made from cream containing 0.45 per cent acid is considerably greater.

Field Work

Work in improving the methods of creamery operation and the quality of the product is being continued at creameries in five States. A general improvement in workmanship and composition control of butter in these creameries has been brought about. This is especially true in the case of one creamery where quality improvement through cream grading has been carried on since 1925. Previous to that time less than 10 per cent of the cream received graded premium and No. 1. After this work was begun the percentage of cream grading premium and No. 1 was as follows: 62.76 in 1925; 66.26 in 1926; and 65.06 in 1927. In 1923 this creamery marketed 281,913 pounds of butter at an average price of 2.88 cents per pound less than the Chicago market price for

90 score butter. In 1927, it marketed 199,029 pounds at .58 cents per pound less than the same market quotation. On the latter quantity of butter the difference in price amounted to \$4,562.73 for the year.

The introduction of the culture method of making Swiss cheese in Ohio and New York showed marked progress. Changes in methods of delivery and handling of milk in the factory resulted in at least 95 per cent of the cheese grading Fancies or No. 1. Favorable comments concerning the work have been received from cheese dealers. At one of these plants slightly different methods of handling milk over a period of 6 weeks resulted in 120 out of 122 cheeses grading Fancies or No. 1.

Cheese made by the culture method exhibited at the Ohio State Fair showed a distinct superiority over nonculture cheese. At the annual meeting of the Ohio Swiss Cheese Association culture cheese scored from 91 to 96½ and non-culture cheese scored from 89 to 92, an average difference of 3.4 points in favor of the culture cheese. Interest in the culture method of making Swiss cheese is evidenced by the additional factories which are adopting it.

Introduction of the manufacture of concentrated sour skim milk as a profitable method of utilizing surplus skim milk has been continued at a number of plants.

Supervision was given the manufacture of nearly one million pounds sweet-cream butter in 10 creameries on contract with the Navy Department. Samples of this product held in cold storage from 9 to 11 months were examined and found to be of excellent quality.

Regular inspection of factories manufacturing renovated butter was continued. This activity is conducted under statutory provision. One additional factory was licensed during the year, making a total of 6 plants.

Milk Utilization

Three milk-for-health campaigns were organized and conducted, two in Washington and one in Virginia. A large number of people were reached in these campaigns. In Grays Harbor County, Washington, a 10.4 per cent increase in milk consumption was reported. In February, 1928, the milk utilization project was discontinued.

Western Office

The western office of the bureau at Salt Lake City, Utah, administers in general the work of the bureau in the 11 Western States.

The bull association investigational project, conducted in cooperation with the University of Idaho has been continued; and a detailed study of 20 associations is being made. The study shows that the size of herds in the associations has increased, on the average, from 5.5 cows to 7.7 cows, or 40 per cent. In addition to improving the production and type of grade herds, the associations are exerting a good influence for the use of better sires in the community.

The market-milk work is making marked progress in interesting the small towns and cities of the Northwest in the improvement of their milk supplies. More than 200 small towns are making use of the surprise plan of inspection. Twenty-nine surprise milk scoring contests, at which 1,342 samples of milk were judged, were held in 7 States. These contests, according to health authorities, State and city inspectors, distributing plants, and owners of dairies, have resulted in the present high standard of quality of milk in the various cities.

The work of the cheese project, comprising the introduction of efficient methods in cheese factories, together with the improving of the quality of milk for cheese-making, was discontinued with the resignation of the specialist in March.

THE BELTSVILLE STATION

T. E. Woodward, Superintendent

The dairy experiment farm at Beltsville, Md., comprises 319 acres. All of the land not used for buildings and yards is used to raise crops for the herd of 270 animals. The farm is operated primarily to provide facilities for various investigations in dairy-cattle breeding, dairy-cow nutrition, market-milk production, and dairy-herd management. Some of the results of the last named project are given herewith.

Feeding and Pasture Experiments

In the interest of economy attention has been given to the most desirable cropping system for the dairy farm. In this connection the question of whether high production can be maintained over a period of years without pasture is important. A tabulation was made of 3 consecutive years' records of 35 cows of an eastern dairy herd. The cows received alfalfa, hay, corn silage, a suitable grain ration, but no pasture. They were dry an average of 11 weeks each year. The results showed that under such conditions a production of 350 pounds of butterfat a year can be sustained without pasture.

Twelve cows in the dairy herd at Beltsville are being fed cottonseed meal in varying quantities with a good roughage of alfalfa hay, corn silage, and pasture grass. As yet no harmful effects have been observed. The test is being continued with a poorer roughage consisting largely of timothy hay and corn silage. The maximum quantity of cottonseed meal which can be fed with safety has not been determined, but apparently 4 to 6 pounds daily with good roughage is not detrimental.

The common method of apportioning grain to lactating cows that are being fed liberal quantities of silage and legume hay is to feed 1 pound of grain for each 3 pounds of milk testing 5 per cent butterfat and 1 to 4 pounds of grain for low testing milk. Investigations have shown that these directions are faulty, because cows will eat more roughage

than is needed to maintain body weight, and also because 1 pound of grain will not supply the nutrients required for 3 pounds of high testing milk or 4 pounds of low testing milk. Thus the low producers are overfed and the high producers underfed. Experiments made at Beltsville with 14 Jersey cows for periods ranging from 2 to 5 months and with 6 Holstein cows for a period of 2 months indicate that when cows are fed 3 pounds of silage for each 100 pounds live weight and all the alfalfa hay they will eat, Jerseys will maintain a milk flow of 10 pounds daily and Holsteins 16 pounds daily without grain. Jersey cows giving milk testing more than 5 per cent butterfat should receive .6 pound of grain for each pound of milk over 10 pounds, and those giving milk testing 5 per cent or less should receive .55 pound of grain. Holsteins giving milk testing 3.5 per cent or less should receive .4 pound of grain for each pound of milk above 16 pounds, and those giving milk testing more than 3.5 per cent should receive .45 pound of grain.

In experiments conducted with 28 calves before which timothy and alfalfa hays were kept at all times, 437 pounds of timothy and 468 pounds of alfalfa were consumed in 60 days. The older the calves the greater the preference for alfalfa. Experiments with calf meals show that the more dried milk there is in the meal the greater will be the growth of the calf. Calf meals containing milk, however, are more expensive than those without it. Results indicate that small calves should gain not less than 100 pounds in 120 days, whereas large calves should gain more. These gains can be made with 300 pounds of whole milk provided the calf meal used contains at least 10 per cent dried milk.

Four years' work in comparing sweet-clover pasture with a mixture of orchard grass, timothy, red top, bluegrass, red clover, and alsike clover, showed that the sweet clover yielded pasture for 1923 cow days on 3.25 acres, whereas the mixture yielded pasture for 1,861 cow days on a similar plot. The sweet-clover pasture cost 13 cents per day per cow; the mixture, 11 cents. In 12 instances out of a total of 21 comparisons in changing the cows from sweet clover to the mixture, the production was greater on the mixture. In

15 instances out of a total of 21 comparisons in changing the cows from the mixture to sweet clover, the production was greater on the mixture. The sweet clover does not stimulate production more than the mixture nor is it ready for grazing any earlier in the spring.

Were it not for the fact that the soil at Beltsville is of such a nature that the sweet clover freezes out badly in the winter, there is little doubt that it would have proved much superior in carrying capacity to the mixture.

Management Problems

The study of the effect of frequency of milking on yield showed that over periods ranging from 217 to 365 days, milking three times a day increased the production 21.3 per cent over twice a day milking. One cow on once a day milking produced 5,291.9 pounds of milk in 365 days, and on twice a day milking she produced 12,078.4 pounds. The conclusion is drawn from these experiments that the oftener a cow is milked, the more persistent is the milk flow. From the first 30 days of lactation to the last 30 days the decline in production was 77 per cent on once a day milking, and only 43 per cent on twice a day milking. The average decline of 8 cows on twice a day milking was 43.5 per cent, and on three times a day it was 22.5 per cent.

Comparisons of the modified Hoard stalls with box stalls in the use of bedding have continued. For cows in Hoard stalls only 4.1 pounds of bedding per cow per day was necessary, whereas previous work has shown that for cows in box stalls 13 to 14 pounds of bedding a day was necessary. Furthermore, the cows in the Hoard stalls were cleaner than those in box stalls.

In the fall of 1926 the four silos at Beltsville were filled with corn without any tramping and with only enough distributing to prevent the cobs from collecting too much in one place. In 1927 the silos were filled without either tramping or distributing. The silage kept perfectly both seasons.

PUBLICATIONS AND EXHIBITS

A. B. Nystrom, in Charge

Forty new and revised publications have been issued during the year. They include 20 scientific papers, 3 technical bulletins, 1 department bulletin, 3 farmers' bulletins, 7 leaflets, 5 circulars, and 1 miscellaneous circular. Three monthly mimeographed circulars have been prepared: (1) the dairy-herd-improvement association letter sent to dairy extension specialists and cow testers, (2) the milk inspector letter, and (3) the milk plant letter. Twenty-two popular articles for publication in yearbooks and trade journals were prepared and edited, and numerous press articles were written for circulation by the Office of Information.

The bureau's contribution to the Radio Service included 16 lectures covering the general field of dairying, particularly the economical production of milk of high quality. Questions were answered regularly every week for the Farm Flash Service.

In cooperation with the Office of Exhibits of the department a special dairy exhibit was prepared by this bureau for the National Dairy Exposition held at Memphis, Tenn., October 15 - 21. The central feature of this exhibit was a barnyard scene where two dairy farmers discussed their problems. The lessons of better dairying which these farmers brought out in their conversation were given to the visitors at the show by means of speaking records. The display also included exhibit groups on the following subjects: Factors affecting fertility in dairy cattle, good cows are the basis of success, the udder - source of a three-billion-dollar industry, effect of high-grade and low-grade legume hay on milking cows, and sterilization of milk utensils. Two exhibits on the subjects of skim-milk powder and milk-plant efficiency were prepared for the Dairy Industries Exposition held at Cleveland, Ohio, October 15 to 20.

A one-reel motion picture entitled "Blood Will Tell" was completed. This film shows how a dairy herd can be improved by the use of good dairy sires, how one community became interested in getting rid of scrub bulls, and how purebred sires are introduced in a community through a better-sire campaign.

RELEASED,

THURSDAY, DEC. 6, P.M.

DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE ENTOMOLOGIST

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 31, 1928.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1928.

Respectfully,

C. L. MARLATT,
Entomologist and Chief of Bureau.

HON. W. M. JARDINE,
Secretary of Agriculture.

INTRODUCTION

The reorganization authorized by the Secretary of Agriculture July 1, 1927, and having for its purpose the bringing together into a new organization, now designated as the plant quarantine and control administration, of all plant-quarantine and related regulatory and control activities of the department, involved the transfer, effective July 1, 1928, to this new organization of the work of this nature hitherto conducted by this bureau in cooperation with the Federal Horticultural Board. The items of work so transferred include the enforcement of the quarantines on account of the gipsy and brown-tail moths, the Japanese and Asiatic beetles, the European corn borer, and, in Hawaii, the Mediterranean fruit fly. The very important research work on these subjects, in all its phases—in biology and natural and artificial control—remains with the bureau. It had long been felt that the growing volume of regulatory work was materially interfering with the development and prosecution of research work which was the primary purpose of the bureau. The separation of the regulatory from the research work will, it is believed, lead to the mutual benefit of both of these fields. A more extended statement of this reorganization is given in the annual report of the Federal Horticultural Board, to which reference is made.

Record should be made in this report of the retirement, effective October 15, 1927, of L. O. Howard from the position of chief of bureau, which he had held since 1894. The position of chief of bureau was filled by the appointment, in succession, of the writer. Doctor Howard will remain, however, in the bureau under the title of principal entomologist, to follow up work along the lines of his special interest. In other departmental publications a full and appreciative record has been made of the important work and achievements of Doctor Howard during his long connection with the department.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS

Investigations of deciduous-fruit insects have been carried out under the direction of A. L. Quaintance, as formerly.

CODLING MOTH

Work on the codling moth has been largely a continuation of that started during the preceding fiscal year as related to the problem of arsenical-spray residues on apples and pears. These investigations, carried on in cooperation with the Bureaus of Plant Industry and Chemistry and Soils, and with several of the States, have shown that many of the arsenical and other compounds tested as substitutes for lead arsenate are not suitable for

use on apples and pears. A number of the compounds have been considerably less effective as poisons than lead arsenate, whereas others have caused important injury to foliage. Among the arsenates tested were those of zinc, aluminum, iron, barium, calcium, copper, titanium, manganese, and magnesium. Tests were also made of various silicofluorides. These studies are being made at the division's field laboratories at Yakima, Wash., Vincennes, Ind., Wichita, Kans., Bentonville, Ark., Moorestown, N. J., and near by, at Sligo, Md. Since the experiments for 1927 indicated possibilities with aluminum arsenate and zinc arsenate these poisons are being further tested. The work planned for 1928 in orchards involved experiments in the use of lead arsenate at different strengths without and with various stickers or spreaders, some plats to be thus treated early in the season, for the control of the first brood and afterwards to be treated with contact sprays and ovicides for the second and later broods. Materials tested as contact sprays and ovicides included nicotine oleate and nicotine sulphate at different strengths, extracts of Derris 1 to 800, extracts of pyrethrum, and white-oil emulsions.

The rapid progress in the perfection of apple-washing machines indicates rather strongly that the use of such machines to remove excess spray residues will prove a most valuable means of meeting the residue problem. Should this be the case the continued reasonable use of lead arsenate, even under conditions of aridity, will be possible. This will be a fortunate outcome in view of the desirable qualities as a spray possessed by lead arsenate, namely, adhesiveness, noninjuriousness to foliage and fruit, and toxicity to the codling moth. Investigations to develop other spray materials will be continued, however, in the hope that something may be found which is less objectionable from the health standpoint than lead arsenate, and which will be equally effective against insects and safe for foliage. In the laboratory in Washington two investigators are devoting the major part of their time to the determination of the lethal doses of a variety of materials for this purpose and to the development of other stomach-poison insecticides. At most of the field laboratories experiments have been carried out in orchards under practical conditions. At Vincennes, Ind., tests of poisons have been made largely in the laboratory and have involved the handling

of 25,000 codling-moth larvæ, although in addition 17 small field plats have been in use. At the Yakima, Wash., laboratory it was ascertained that in control value five applications of double-strength lead arsenate were equal to six applications at the normal strength, and that four double-strength applications nearly equaled five applications at the usual strength. The use of oil sprays with lead arsenate generally gave better control than was obtained with lead arsenate alone, but the oil has certain definite effects on the tree and fruit which need further study to determine whether they constitute injury. Nicotine sulphate, 1 to 800, used in three cover sprays, following a calyx and a first cover application of lead arsenate, resulted in very favorable control. In this connection it was found that nicotine sulphate kills about 15 or 20 per cent of codling-moth eggs and has a very decided effect in checking the entrance of worms, even for from 12 to 15 days after it has been applied. To supplement spraying, further attention was given at the Yakima laboratory to the use of bait traps. It was found that by this means an important number of moths could be caught and destroyed but, in these tests, not sufficient numbers of them to effect control. In cooperation with the Bureau of Chemistry and Soils studies were undertaken in the spring of 1928 to ascertain what constituents of the fruit juice and other baits are most attractive to the moths.

Further progress has been made in the development of the automatic or self-working codling-moth bands for application to the trunk and limbs of apple and pear trees. Bands soaked in lubricating oil containing beta naphthol have continued to give good results. As a mimeographed circular giving instructions for the preparation of the bands has been issued, and as the bands have been made available to orchardists by a manufacturing concern, they will probably receive extensive tests during 1928. According to the bureau's observations the bands, if properly made and applied, are nearly 100 per cent effective in destroying all codling-moth larvæ which spin up under them throughout the season, and thus far there has been no important injury to the bark of the trees from their use. Careful studies of the possible repellent action of the treated bands as compared with untreated ones indicate that the larvæ go just as readily to the treated as to the untreated bands.

GRAPE-BERRY MOTH

As in the instance of the codling moth, investigations in the field of grape insects have been largely a continuation of the work undertaken during the preceding fiscal year in connection with the spray-residue problem. In the control of the grape-berry moth especially, midsummer sprayings have been necessary, which leave a very decided residue on the grapes at picking time. The experiments undertaken therefore have been to ascertain to what extent this and other grape insects could be controlled by very thorough early spraying with increased dosages of lead arsenate, and whether sufficient residue would persist at harvest time to exceed the tolerance allowed for arsenic. In this connection arsenates of calcium, magnesium, aluminum, zinc, manganese, iron, etc., have been tested. Tests were also made with various oils, alone and combined with lead arsenate; with nicotine sulphate, alone and combined with lead arsenate; with pyrethrum-soap combinations; with cuprous cyanide; with the fluosilicates of potassium, sodium, and barium; and with shale oils. In addition, large-scale experiments in vineyards have been carried out with commercial lead-arsenate dust in the hope that control of the berry moth could be accomplished without the usual spray-residue effect.

The results in the fall of 1927 indicated that several of these materials were worthy of further experimentation, and consequently they were put under test again in the spring of 1928. Aluminum arsenate, calcium arsenate, and tricalcium arsenate, as well as magnesium arsenate, in two experiments gave the same control of the berry moth as lead arsenate, two applications giving a fair control, whereas three applications gave notably better results as compared with the condition of untreated checks. Zinc arsenate, ferric arsenate, and manganese arsenate caused some burning of foliage or damage to grape clusters, and gave lower percentages of sound fruit. With the other materials, including lead arsenate, no serious injury to foliage was apparent. An analysis of samples of ripened grapes from these various plats, made by the food, drug, and insecticide administration, showed that with the most promising materials the quantity of arsenical residue present on grapes is approximately the same as on grapes sprayed with lead arsenate and near or above the tolerance allowed. In a large-scale experi-

ment in the field, in which spraying after midsummer against later broods of the berry moth was omitted, it was found that while the quantity of residue at harvest time was within the tolerance, the control of the berry moth was unsatisfactory. A miscible-oil emulsion and two white-oil emulsions tested at 1, 1½, and 2 per cent strengths gave poor results in the control of the berry moth. Although some of the eggs present on the berries and foliage at the time of application were destroyed, the oils did not affect the larvæ entering the grapes; furthermore, some injury to foliage resulted. The natural bloom of the grape berries was destroyed, and this effect gave the fruit an unattractive appearance. The use of nicotine sulphate at a dilution of 1 to 800 resulted in the destruction of some of the eggs of the berry moth present at the time of spraying, but did not provide sufficient protection to produce a yield of marketable grapes under conditions of heavy infestation. Similar unsatisfactory results were obtained with a commercial preparation of Derris, said to contain 5 per cent of Derris resins, when used at a strength of 1 to 800. Sodium silicofluoride was found to be highly toxic to grape foliage; it was less injurious when used with Bordeaux mixture or with lime, but its toxicity to insects was then reduced.

It would appear that the greatest hope of controlling the berry moth without objectionable spray residue will come from very intensive spraying of vineyards early in the season with lead arsenate, so that the later broods will be of minor importance; such spraying must be reinforced by certain cultural practices calculated to destroy the overwintering grape-berry moths, and such systems of vine training must be adopted as will permit of thorough spray applications. There is, of course, hope that methods of washing grapes similar to those employed in the case of apples and pears may be developed. Preliminary experiments along this line indicate, however, that there are numerous conditions to be met in the washing of grapes that are not present when apples or pears are to be washed.

PEACH INSECTS

Experiments have been continued on the Oriental fruit moth at the laboratories at Moorestown, N. J., and Fort Valley, Ga. At the Moorestown laboratory the work was principally along three lines, namely, a continuation of life-history investigations and studies

of biological control and of insecticides. The growing season of 1927 fairly concluded a detailed study of the life history and habits of the fruit moth, and the data are being assembled for publication. The investigations of biological control have dealt principally with detailed studies of the life history and habits in the laboratory and field for four species of parasites, namely, *Macrocentrus ancylivora*, *Glypta rufiscutellaris*, *Ascogaster carpocapsae*, and *Trichogramma minutum*. As the last two species also attack the codling moth, this insect, too, has been used as a host in these studies. Three years of careful field and laboratory work have now been accomplished with *M. ancylivora*, which is the most important parasite in the vicinity of the laboratory and in the southern half of New Jersey. This species is very abundant when twig infestation runs high and apparently has been responsible for a decided reduction in the number of the insect late in the season. Observations have also been made on *G. rufiscutellaris*, a form very abundant in the northern half of New Jersey, even more so than the one first mentioned. Particular attention has been given to a life-history study of the little egg parasite *T. minutum*. This parasite has a large list of hosts and readily attacks the eggs of the Oriental fruit moth and the codling moth. These studies have developed the relationship existing between temperature and the rate of development. It was found that there were at least 13 generations of the *Trichogramma* last season, and the length of the life cycle ranged from 8 to 65 days. When the temperature averaged 80° F. a generation was completed in 8 days, whereas when the temperature averaged about 50°, 50 to 65 days were required to complete a generation. A few individuals overwintered in eggs of the Oriental fruit moth. In the insecticide studies ovicides, repellents, and winter washes have been given special attention. Various winter washes to destroy the insects in overwintering cocoons were tried, but most of them gave negative results, and from our present information this method of attack is not considered very hopeful.

At the Fort Valley, Ga., laboratory most of the time was devoted to working up laboratory notes, accumulated during the years 1925 and 1926, on the life history of this species under conditions prevailing in the South. Scouting through this section showed a great increase in the area infested,

although the damage continues to be light. At this laboratory investigations of attractants and repellents for injurious peach insects have received major attention, the plum curculio and the peach borer being the forms principally involved. Preliminary work in the laboratory has been accomplished mostly by means of olfactometers, while evaporation cups and traps have been used in orchards. A large list of possible attractants have been under test against the plum curculio, and to date this insect appears rather more attracted to certain phenols than to other chemicals. Tests have been under way to determine the toxicity of the fluosilicates of sodium and calcium and of a number of arsenicals as insecticides against the plum curculio. Sodium fluosilicate without lime, both as a dust and sprayed as a mixture of 2 pounds to 50 gallons of water, was the most toxic to the plum curculio of all the insecticides tested. Spraying experiments with this compound without lime showed, however, that it was very toxic to peach foliage and fruit. Although lime corrected the burning effect of the insecticide, making it even safer than lead arsenate, it largely destroyed its toxicity for the plum curculio. Since sodium fluosilicate has several important advantages over lead arsenate for the plum curculio on peach, it will be given further attention in the hope that some way may be worked out whereby injury to foliage may be obviated. Laboratory studies have been completed on the effects of hydrogen-ion concentration upon the arsenates of acid lead, tricalcium, zinc, aluminum, barium, manganese, and magnesium. Considerable correlation has been found to exist between the burning produced upon peach foliage and the speed with which these arsenates decomposed in a solution having a pH equal to the acidity of rain or dew. Correlation was also found to exist between the toxicities to insects of these arsenicals as reported by various investigators and the speed with which they decompose in a solution of the approximate acidity of the digestive tract of an insect. These studies, therefore, suggest a possible method for the prediction of the probable comparative toxicities to foliage and insect of a series of insoluble salts of a given acid. Acid lead arsenate was found to be nearest to the ideal insecticide of all those tested. Its decomposition was the least rapid at the pH of rain and dew and the most rapid at the

approximate pH of an insect's digestive juices.

Work has been continued with paradichlorobenzene for the peach borer. It has been found, as formerly, that practically no injury results to 4 or 5 year old trees with a dosage of three-fourths ounce and to 6-year-old trees with a dosage of 1 ounce. Some of the 1-year-old trees were injured by the one-fourth ounce and one-half ounce doses for 2 and 4 weeks, and some of the 2-year-old trees were injured by one-half ounce and three-fourths ounce doses for 2 and 4 weeks. There was light injury from the one-half and three-fourths ounce doses for 4 weeks around 3-year-old trees. At the Sligo, Md., laboratory further tests have been made with paradichlorobenzene dissolved in high-test gasoline applied around the bases of peach trees. The results have shown that this method of application, without preparation of the soil before treatment and without banking with soil after application, is as effective as the application of the crystals made in the usual way. Further experiments will be necessary, however, to ascertain the exact status of this method of application of the chemical. Tests carried out with cloth bands and crepe-paper strips treated with beta naphthol and red engine oil applied around the bases of peach trees indicate that such treatment is dangerous to the health of the trees.

At the Vincennes, Ind., laboratory further observations were made on the insects involved in the so-called "cat-facing" of peaches, especially with reference to tests of materials which might prevent the trouble. In this connection cresylic-acid dust, calcium-cyanide dust, nicotine dust, and nicotine liquid were put under test. Preliminary examination indicates that none of these materials will give a satisfactory control.

NUT INSECTS

Investigations of nut insects are subdivided into those on nut insects in general and those on insects affecting the pecan. Headquarters for the former work is at French Creek, W. Va. Here the various insects attacking nuts other than the pecan are being investigated as opportunity offers. During the last fiscal year special attention was given to parasites attacking the hickory twig girdler, which has been quite destructive at Petersburg, Va., French Creek, W. Va., and other localities. The twig girdler now appears to be on the decline,

largely owing to the valuable work of some seven or eight species of parasites which have been found attacking the eggs and young larvae of this species. Progress was made during the year in studies of several weevils of the genus *Curculio* attacking nuts and acorns. Extensive rearings have been made of these weevils, especially of the two species *Curculio proboscideus* and *C. auriger*, both injurious to chestnuts. Special attention has been devoted to methods of destroying these weevils while they are undergoing transformation in the soil and to the preoviposition habits of the beetles on the trees. It has been found that beetles of *C. auriger* feed on fruit juices, and that the species attacking chestnuts feed freely on honey thinned with water and on water otherwise sweetened. Experiments were made to determine whether use can be made of these feeding habits to accomplish the weevils' destruction. With the blighting and dying of native chestnut trees in the East there is an awakened interest in planting other nut-bearing trees to take the place of these dying chestnuts. Thus the hazel nuts, both American and European species, are being more extensively planted than previously. Particular attention has been given to an enemy of the hazel, *Agrilus arcuatus*, which girdles and kills small twigs of these plants. In addition the hazel curculio, *C. optusus*, and two other species of *Agrilus* beetles are under study, as the three forms threatened to stand in the way of the successful growing of these nuts.

Investigations of pecan insects are being carried out, headquarters being located at Albany, Ga., and sublaboratories at Barnesville, Ga., and Brownwood, Tex. At Albany, Ga., tests are under way, in cooperation with the office of cotton-insect investigations of this bureau and with the Bureau of Plant Industry, to determine the practicability of controlling foliage-destroying insects by dusts of calcium arsenate applied by airplane. Special studies are being made of the biologies of several pecan pests, as the shuckworm, nut case bearer, etc., including their various parasites. At Barnesville, Ga., the nut weevils and certain borers which have become quite troublesome in the surrounding district are receiving major attention and satisfactory progress is being made. At Brownwood, Tex., the so-called "black pit" and "kernel spot" are receiving special attention, as well as the shuckworm, nut case bearer, and other important forms.

BLUEBERRY MAGGOT

Experiments in the field and laboratory in the Washington County, Me., area were continued during the fiscal year along much the same lines as previously, though these were materially enlarged in some particulars. In connection with the life-history investigation it has been ascertained that the flies begin to emerge late in June, increase rapidly during the first week of July, the peak of emergence being reached about the middle of the month. During the last 10 days in July emergence declines rapidly and practically ceases by August 1. It appears that the preoviposition period of the adult averages about 13 days and the period of oviposition about 6 days. Egg laying began about July 11 and reached the peak about July 28. About July 16 egg hatching was observed and reached its maximum about August 3. These observations indicate an incubation period of about 6 days at the beginning and about 5 days during the height of the season. Maggots are present in the berries in maximum numbers about August 10. At this time pupation begins, reaching its maximum about August 17. These life-history facts are utilized as a basis for the most effective application of calcium-arsenate dust to the plants, the effort being to poison the adults before they have oviposited to any extent.

Besides further tests with the poisons additional studies were made of the possible value of burning over the blueberry land, a practice heretofore much followed. It was ascertained that the burning process as ordinarily conducted failed to raise the soil temperature materially, and therefore is not effective in destroying the puparia below the surface of the soil. There are indications that double burning—that is, burning over the land two years in succession—will be more effective, since some of the puparia of the flies remain in the soil for two years before flies emerge, and are an important factor in the infestation of the first crop of berries after the land has been burned over. Experiments to ascertain the exact value of double burning are under way, but the results will not be available until the summer of 1929.

Further attention is being given to the collection of fruits of various kinds for determination of infestation by maggots. Puparia of the blueberry maggot were obtained last year from *Crataegus* sp., chokeberry, wintergreen

berries, bunchberry, mountain holly, and *Vaccinium corymbosum*. Further study was given to parasitism by *Opius melleus*, which has been found to vary from 1 or 2 per cent to 40 or 50 per cent. The adult of this parasite emerges somewhat later than the adult of its host, a fact which indicates the possibility of destroying the fruit flies by a dust application of calcium arsenate in sufficient time to permit the adults of the parasite to escape injury from the poison.

Rather extensive experiments were carried out during the year by means of high-power orchard dusters. About 50 acres was under experiment, the dosage of poison ranging from about 3½ to 10 pounds per acre. Every experiment showed considerable reduction in the number of maggots in the blueberries as a result of the treatment. Tests were also made of calcium-arsenate dust to which powdered sugar had been added. Although this experiment was somewhat inconclusive because of rather low initial infestation, the advantage of the added sugar was not very apparent in comparison with calcium arsenate powder alone. Analyses of blueberries from the poison-dusted plats gave less than 1 part of arsenic per million, and in many samples there was only a trace of arsenic at picking time. It is felt, therefore, that there is but little, if any, danger that the blueberries will carry objectionable quantities of arsenic at harvest time.

PREVENTING SPREAD OF THE JAPANESE AND ASIATIC BEETLES

This work has continued under the direction of Loren B. Smith.

JAPANESE BEETLE

During the period under review the area infested by the Japanese beetle was enlarged to include 19,827 square miles, an increase of 5,908 square miles above the area in 1927. In Connecticut 12 additional townships south of the Housatonic River, including the city of Bridgeport, were found to be infested. The discovery of new colonies of the insect on Long Island made it necessary to include the entire island within the regulated area. Infestations were found in many localities in the coal-mining region of Pennsylvania. A small infestation of beetles was found at Gettysburg, and a single beetle at York, Pa. Small colonies of beetles were discovered at Clayton and Dover, Del. Several in-

festations were located in the State of Maryland; these occurred in the towns of Cambridge, Ridgeley, Chesapeake City, Perryville, and the city of Baltimore. Several beetles were discovered in the District of Columbia.

The area heavily infested by the Japanese beetle increased considerably in 1927. Severe injury to shade trees, ornamental plants, and field crops was noted in portions of Delaware, Chester, Montgomery, Philadelphia, and Bucks Counties, Pa. Injury by the insects was evident in Salem, Gloucester, Atlantic, Burlington, and Mercer Counties in New Jersey. The periodic appearance of large numbers of Japanese beetles in the business section of Philadelphia was more pronounced than in any previous year. In general, the damage caused by the beetles was equally as severe as in former seasons. The most notable feature of the year was the severe injury to sweet and field corn resulting from the feeding of the beetle on the silk and tips of the ears. This damage was general throughout the heavily infested area. Thorough and timely spraying continued to afford excellent protection to fruit and ornamental trees. Satisfactory methods for the protection of early-ripening varieties of peaches and of small fruits still remain to be developed.

RESEARCH

Certain difficulties were encountered in the manufacture of oleate-coated lead arsenate on a commercial basis. It was necessary to spend much time and effort in improving methods for its manufacture in order to assure the production of a standardized article which would give the results desired. This material more than any other has enabled the general public to protect their plants from the attacks of the beetles, and is undoubtedly the most generally used insecticide for control of the Japanese beetle. The adhesive and spreading qualities of this material have been much improved, and under all ordinary conditions one application is sufficient to protect plants from the Japanese beetle throughout the season. Since it has been necessary to apply lead arsenate to early ripening apples shortly before they are harvested in order to protect them from attack, investigations are being conducted for the purpose of developing a nontoxic repellent which will leave no residue on the plant.

Lead arsenate has been considered a repellent rather than a stomach poison, since relatively few of the adult beetles

consume a killing dose of the chemical before they stop feeding. It has been found that when certain types of highly refined sugar sirups are combined with lead-arsenate sprays the beetles will consume a sufficient quantity of the poison to kill them. The insects usually remain on the tree or plant until they die, and many thousands of dead beetles can be observed under trees treated in this manner. Further investigation is necessary in order to overcome certain objectionable features of this mixture. When lead arsenate is sprayed on ornamental plants, the white color of the residue detracts from the appearance of the plant. To overcome this objection a green arsenate of lead was developed and has proved quite satisfactory.

An improved pyrethrum soap, prepared with a coconut fatty acid and containing sodium silicate, has been developed. It is considered a distinct improvement over the pyrethrum soap previously recommended by the laboratory, which is now being sold commercially. Investigations are being continued on the development of traps for capturing the Japanese beetle. The traps are baited with a combination of geraniol, eugenol, bran, molasses, and glycerin. Considerable improvement must be made in the design of the traps, however, before they can be generally recommended except as an adjunct to other means of control.

Progress has been made in the investigation of the use of hot water as a control for the larvæ of the Japanese beetle in balled nursery stock. Approximately 100 varieties, including 200,000 individual plants, have been treated under commercial conditions. The results show that many varieties of nursery plants can be successfully treated with water at temperatures between 110° and 112° F., and that infestations of larvæ can be destroyed without injury to the plant. The development of this treatment and its general use by the trade will effect the saving of many thousands of dollars to the nurserymen in the territory infested by the Japanese beetle. A new formula for the preparation of an improved carbon-disulphide emulsion has been developed, and the emulsion, known as miscible carbon disulphide, has been commercialized. It has been used extensively and with excellent results. Investigations have shown that under certain conditions naphthalene is an extremely effective insecticide, and work is now under way to find means whereby it may be used in soil.

Studies are being continued for the purpose of obtaining further data on the reaction of the Japanese beetle to its environment and its probable importance as a pest when it reaches other regions of the United States. At the close of 1927 it was well and firmly established in the Piedmont region of Pennsylvania. There has been some doubt whether the insect would multiply as rapidly and cause as serious damage in the Piedmont as it has done in the coastal plain area. The information accumulated during the past year indicates that the beetles have found favorable conditions for development throughout most of the northeastern part of the United States. Studies are being continued on the general ecology, life history, and biology of the Japanese beetle.

Unquestionable proof has been obtained that the dextid parasite *Prosema siberita* has become established in the vicinity of Moorestown, N. J. Recoveries were made of adults of this parasite in New Jersey in the summer of 1927, and again in the spring of 1928. Another dextid, *Dexia ventralis*, a parasite introduced from Chosen (Korea), has been recovered in New Jersey during the past year. The tachinid *Centeter cinerea*, introduced several years ago, has increased its distribution in New Jersey and Pennsylvania to include an area of approximately 75 square miles. Additional colonies of this parasite were liberated at Harrisburg, Pa., and Bridgeport, Conn., late in the spring of 1928. Strong colonies of the three introduced species of *Tiphia* wasps have been established in Long Island, New Jersey, and Pennsylvania. During August, 1927, the adults of *Tiphia popilliacora* were found to be extremely abundant in an area near Riverton, N. J. This colony was so vigorous that it was possible to establish 10 subcolonies in New Jersey and Pennsylvania without detracting materially from the strength of the parent colony. Shipments of the several parasites are being made from India, Japan, Chosen, and China, and the importations are being enlarged and expedited, particularly of those species which are now known to survive successfully the conditions found in this country.

QUARANTINE ENFORCEMENT

The Bureau of Entomology, cooperating with the Federal Horticultural Board and the States of New Jersey, Pennsylvania, Delaware, New York,

and Connecticut, has continued the enforcement of Federal and State quarantines to prevent the spread of the Japanese beetle. A revision of the quarantine was made in the fall of 1927. Infestations of the Japanese beetle found at points in Maryland distantly removed from the main infestation presented the problem whether large areas of uninfested territory should be included in the regulated area or whether attempts should be made to exterminate such distant infestations. There appeared to be a reasonable chance for success in an extermination campaign in the areas in Maryland, Delaware, and Pennsylvania. The Federal Horticultural Board agreed to withhold the extension of the regulated area to include Maryland until the summer of 1928, when the results of the work done there could be determined. The actual treatments for extermination were given by the several State departments of agriculture under the supervision of Federal inspectors. The treatments included the application of carbon-disulphide emulsion to approximately 5 acres of soil at each point where infestation had been found, and were concluded late in the spring of 1928. The shipment of all nursery stock from these areas was supervised and regulated by the several States in order to safeguard such movement and prevent the possibility of transporting any infestation of Japanese beetles.

During the summer of 1927 the inspection of farm products was required between June 15 and October 15; this included the inspection of fruit and vegetable products, with the exception of certain roots and seeds. The regulations require the inspection of nursery and greenhouse products, including sand, soil, earth, peat, compost, and manure throughout the year. Because of the large regulated area this method of quarantine enforcement was changed somewhat from the system maintained during previous years. Formerly the inspectors have been stationed at strategic points, subject to call by the growers. Under the new arrangement the growers presented at certain points, for inspection, their products which were to be transported from the quarantined area. Patrols were established on the majority of roads leading out of the regulated area for the purpose of preventing the movement of contraband articles of produce. It was the duty of road inspectors to examine all trucks and

vehicles passing out of the regulated area and to make sure that they carried no uncertified or contraband products. The presence of large numbers of beetles in the downtown districts of Philadelphia at certain times during the summer made it necessary at times to discontinue all inspection and certification after 10 a. m., the time when the beetles usually become active.

The inspection and certification of nursery stock and ornamental plants has been conducted on much the same basis as in former years. Improved methods of soil treatment have been devised whereby it is possible to destroy any infestation of the Japanese beetle which may exist in the soil about the roots of plants. All treatments of plants are given under rigid safeguards and are supervised by specially trained inspectors. The total number of plants certified for shipment out of the regulated area during the past calendar year amounted to 76,155,423. These were consigned to 48 States, Canada, Mexico, and many foreign countries. Ten thousand two hundred and six carloads of sand or soil were shipped from the regulated area to all the States and to Canada, 525 carloads of manure, 5,905,021 packages of farm products, and 55,507 bales of hay and straw; 25,279 boxes of cut flowers were inspected and certified for shipment from the regulated area. A total of 711,689 certificates for shipment were issued during the year.

Eight thousand one hundred and fifty-eight nursery plants were treated under field conditions and 17,674 plants were treated by the tank method. In addition, 2,166 cubic yards of potting soil were fumigated under the supervision of inspectors in the several nurseries.

Ninety-five bona fide violations of the quarantine regulations were discovered. Twenty-six of the cases were prosecuted, 2 held in abeyance, and 67 filed without action. A total of \$430 was collected by the courts in fines.

As a means of determining the spread of the Japanese beetle from year to year scouting crews were established in the territory adjacent to the periphery of the known infested area. Intensive scouting brought to light in 1927 infestations in the State of Maryland, the District of Columbia, and elsewhere. It is possible by this means to obtain fairly accurate information relative to the distribution of the Japanese beetle.

ASIATIC BEETLE

Investigations of the Asiatic beetle, *Anomala orientalis*, have been continued and enlarged during the year. A small field laboratory has been established at Westbury, N. Y., for the purpose of studying the biology of this insect, as well as to devise improved methods for its control. It has been found that certain parasites which are effective against the Japanese beetle are also useful in the control of the Asiatic beetle. Efforts are being made to establish the several species of Japanese-beetle parasites in Long Island and Connecticut to assist in the control of the Asiatic beetle. As the Japanese beetles also occur in small numbers in both of these areas, the establishment of the parasites at suitable points will be of great help later in controlling the Japanese beetle as it becomes more abundant there.

OTHER BEETLES

Preliminary studies of another beetle from Japan known as *Autoserica castanea* Arrow, occurring in the vicinity of New York City and on Long Island, indicate that it is a somewhat serious pest. It feeds at night on many ornamental plants, as well as on fruit, and causes considerable damage. Still another Japanese species closely related to this insect has been discovered on Long Island. It is known as *Serica similis*, and is reported as injurious in Japan. Thus far it has been found in very small numbers, and it has not yet been possible to determine whether it may prove a pest in this country.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH

The activities of this project have been continued with A. F. Burgess in charge.

RESEARCH WORK

The investigations in foreign countries during the year have included (1) surveys in Italy, northern Africa, and central Europe, (2) biological work, and (3) shipment of parasites to the gipsy-moth laboratory at Melrose Highlands, Mass. No infestations were found in Italy that were large enough to produce parasites in sufficient quantities for shipments, but it was possible to forward several small shipments from Algeria. Owing to

delays in transit, the shipments did not arrive in this country in good condition, and only a few hundred live specimens of *Tricholyga segregata* and *Brachymeria intermedia* survived. An attempt has been made to breed up this material to increase the stock for colonization. Two entomologists have carried on work in central Europe with headquarters at Budapest. Biological investigations have been conducted with the parasites that appear likely to prove of importance if they can survive in America, and particularly those species that have more than one generation in a year and require a secondary host. Some progress has been made, but more work of this type is urgently needed. During the summer of 1927, 100,000 parasites, chiefly in the dormant stage, were collected in Poland and Hungary and shipped to the Melrose Highlands laboratory. These were mostly tachinids, although some hymenopterous parasites were forwarded.

During the year over 4,600,000 parasites have been liberated, over 4,000,000 of which have been the egg parasites *Schedius kuvanae* and *Anastatus bifasciatus*.

Collections from many parts of the infested territory indicate that the average percentage of parasitism is slightly greater than was that of the previous year 1926-27, the two egg parasites above mentioned, *Apanteles melanoscelus*, *Compsilura concinnata*, *Sturmia scutellata*, and the predacious beetle *Calosoma sycophanta* showing some gains. By using a specially designed trap which was referred to in the report of the last fiscal year some surprising records of the population of this beetle have been obtained. Over 2,000 beetles per acre have been collected from some selected areas, and this emphasizes the important rank which this beetle holds among the natural enemies of the gipsy moth.

Parasitism of the brown-tail moth has increased somewhat, although the small larvæ in the winter webs have been attacked a little less than usual.

In the summer of 1917 a bacterial disease, *Streptococcus disparis* Glaser, was introduced from Japan and liberated in the field. Specimens of gipsy-moth larvæ were found in small numbers this year which appeared to have died from this cause. Whether or not this species will increase more rapidly in the future remains to be determined.

Recent experiments with the use of fish oil as an adhesive for lead-arsenate sprays have shown that effective

results can be obtained with a reduced dosage of poison. The quantity has been cut this year from 6¼ to 5 pounds of lead arsenate to each 100 gallons of water for field application, and further tests are under way to determine whether even less poison can be used on all kinds of foliage and reliable results be still obtained.

Experiments in dusting by airplane did not give uniformly favorable results in the summer of 1927. One of the great difficulties encountered was the ease with which the dust was washed from the foliage by rain. Accordingly an attempt is being made to find some type of sticker that will remedy this difficulty, and several materials are now being tested.

QUARANTINE AND INSPECTION IN COOPERATION WITH THE FEDERAL HORTICULTURAL BOARD

On July 1, 1927, the gipsy moth and brown-tail moth quarantine was revised, and 13 towns in northern Vermont and 2 in Connecticut were released from the quarantined area. This release was not sufficient, however, to reduce materially the inspection work for the quarantined area as a whole. On July 1, 1928, the foreign quarantine prohibiting the shipment of Christmas trees to the United States from a tier of towns north of the international line in Quebec was withdrawn, and such action was made possible as a result of the effective eradication measures enforced by the Dominion of Canada, resulting in the apparent extermination of the gipsy-moth colony near Henrysburg, Quebec, which was the basis of the quarantine.

The following shipments were inspected and certified during the year, those that are recorded as infested having been cleaned before they were allowed to move: In all, 133,585 shipments were inspected and certified. These comprised 34,833 shipments of nursery stock, none of which was infested; 6,365 shipments of forest products, 35 of which were infested; 90,478 shipments of stone and quarry products, 24 of which were infested; and 1,909 shipments of evergreens, none of which was infested. In the 35 infested shipments of forest products were found 1,890 egg clusters, 84 larvæ and pupæ, and 1 adult of the gipsy moth, and 1 egg cluster and 1 adult of the satin moth. In the 24 infested shipments of stone and quarry products were found 339 egg clusters and 776 larvæ and pupæ of the gipsy moth and 5 adult brown-tail moths. The number of permits issued for the movement of

products originating outside the quarantined area was \$51, and the number of permits authorized by regulation No. 6 of quarantine No. 45 was 9,168.

The number of shipments is not an accurate index of the quantity of material certified or released under permit, as a shipment may mean a carload or barge load of material forwarded under one certificate or a single tree, shrub, or block of granite sent as an individual order. The volume of nursery stock certified during the year was greater than usual, but shipments of stone and quarry products and Christmas trees declined slightly.

EXTERMINATION WORK IN NEW JERSEY

For the first five years after the gipsy moth was found in Somerville, N. J., every effort was made to discover and treat all the infested localities, and many difficulties were experienced during that period. This work involved an area of over 400 square miles. In 1925 this region was handled by scouting localities where colonies had been found previously, and other areas under suspicion of infestation. The greater part of the work was done in a belt of towns approximately 10 miles in width, beyond the periphery of the known infested area, to determine the possible spread of the insect. This general plan has been continued since that time, the purpose being to close in gradually on the area that was originally infested. Each year the scouting has been intensified and has been followed up by thorough cleaning and spraying throughout the area where there was any trace of the insect.

The southern part of the area has been relatively free from infestation, but the work in the fiscal year 1927 developed the fact that a few small colonies were present in the heavily wooded territory north of Somerville and also in the township of Mendon; in all, 12 small colonies were found and treated. During the present fiscal year these areas have been reexamined, as also have the following townships or parts thereof: Branchburg, the southern part of Hillsboro, a section of Montgomery, Franklin, the western portions of North Brunswick, and a considerable area in North Plainfield. Five small colonies, aggregating 70 egg clusters, have been found, two of these being in Hillsboro, two in Warren, and one in North Plainfield. The scouting has been more intensive than

ever before, and, as the northern part of the territory is heavily wooded, progress there is relatively slow.

All the spraying was done in the spring, as planned, although the extremely wet season caused considerable delay. Two thousand four hundred and twenty-nine shipments of trees and other material were inspected and certified, in accordance with the provisions of the New Jersey State gipsy-moth quarantine.

The results of the season's work in New Jersey have been very gratifying, and continued progress has been made in the extermination of the insect in that State. Hearty and effective cooperation with the State department of agriculture has been maintained as heretofore.

THE BARRIER-ZONE PROJECT IN NEW ENGLAND AND NEW YORK

Work on the barrier-zone project was begun in the spring of 1923, in cooperation with the department of conservation of the State of New York.

In the report for the fiscal year 1925 attention was called to the rapid increase of the gipsy moth in the Cape Cod section of Massachusetts, and it was pointed out that if this condition should develop in the western part of the quarantined area the barrier zone would be threatened.

Infestation in the eastern part of the area became worse in the fiscal year 1926, the area defoliated being more than doubled. A few infestations large enough to cause some defoliation were also found at Springfield, Vt., and Deerfield, Mass., on the west side of the Connecticut River, as well as at points east of the river and in New Hampshire. The infested areas were treated by State and town officials.

To determine the trend and amount of increase near the barrier zone, two groups of towns lying directly east of the zone in Vermont were examined during the fiscal year 1927. Three heavy infestations were found in that State, one each in Pittsford, Rutland, and Ira. The colonies were promptly treated, and no infestation has since been found in the localities named. Had the colonies been allowed to increase for another year or two, the adjoining towns in the zone would have become infested.

Early in the spring of 1927 reports from the State and local authorities working in the territory between the zone and the Connecticut River in Massachusetts showed that the in-

crease in the number of egg clusters over that of the previous year amounted to 215 per cent.

During the summer of 1927 the area defoliated in the eastern part of the territory nearly doubled, marked increases in area occurring in Massachusetts and New Hampshire, while in Maine the largest acreage of defoliation was recorded since the gipsy moth was first found in that State. In Rhode Island more defoliation occurred in the southern part of the State than had ever been noted in previous years.

The results obtained and the reports of State and local authorities indicate clearly that the infestation in many areas has continued to increase. In some towns many small infestations are present in all sections of them. This situation makes the problem far more difficult than heretofore, and forecasts a heavy spread of the pest into the barrier zone as soon as these small, scattered colonies have sufficient time to increase. Some of these colonies are so near the eastern line of the zone that heavy spread may occur unless effective work is carried on before the larvæ hatch in the spring of 1929.

Conditions in the barrier zone show improvement in the northern and in the southern part, except in the town of Wallingford, Conn., where a large woodland colony was found in 1928. The territory in the southern part of Berkshire County and in northern Connecticut developed more infestations than usual and is now the most threatening area in the zone. Several colonies were found in 1928 in the New York area of the zone by the New York State department of conservation, immediately west of the area just mentioned. These are larger infestations than have usually been discovered in that State.

Although complete information is not now available, it is known that the acreage of defoliation in New Hampshire in 1928 will far exceed that of the last few years, and it is believed that the total defoliated area for the entire infested district will be considerably larger than in 1927. Heavy defoliation occurred farther west in Massachusetts and New Hampshire than heretofore; several small areas have been reported in southeastern Vermont, and in a few towns west of the Connecticut River in Massachusetts considerable partial defoliation was found. The continued increase in defoliation during the past four years

has reached a point where it will be necessary to carry on scouting and control operations in a wider belt of territory in the western part of the area if the advantages that have been secured in the barrier zone are to be maintained.

The infested territory along the eastern and northern peripheries of infestation in Maine, New Hampshire, and Vermont has not been inspected for several years. This work has been deferred on account of the more pressing needs in the zone area and because no serious infestations were known to occur that indicated the likelihood of immediate danger. On account of the rapid increase and annual movement of defoliated areas toward these borders, a band of towns should be scouted during the present fiscal year to determine more accurately for quarantine purposes the extent of spread of infestation.

CEREAL AND FORAGE INSECT INVESTIGATIONS

Investigations of cereal and forage insects have been carried out under the direction of W. H. Larrimer, as formerly.

EUROPEAN CORN BORER

The gradual spread of the corn borer toward the Corn Belt from the region of the Great Lakes has continued during the year, and although the benefits derived from the clean-up campaign of 1927 were substantial in preventing commercial damage to the corn crop the natural spread of the insect by flight has continued. This is particularly true of Ohio and Indiana, where the areas found infested in 1927 were considerably greater than was the case during the previous summer. Much of the spread in Ohio occurred in an area that was contiguous to the section which it was necessary to exempt from clean-up in 1927. In this connection it should be observed that some of the apparent spread of 1927 may have occurred in 1926, but owing to the less adequate scouting facilities available in that year this infestation may not have been discovered until 1927, when a greater and more efficient scouting corps than ever before was thrown into the field. It is believed that as a result of this action the limits of the territory occupied by the corn borer are now more exactly known than ever before. In this connection it is inter-

esting to note that the area found newly infested in southern Michigan in 1927 was much smaller than it was the previous year. The western boundary of the infested territory has now reached the center line of Indiana on the west and has advanced beyond central Ohio on the south. A more detailed report on results of scouting and other quarantine activities will be found in the annual report of the Federal Horticultural Board.

As a result of the continued urgent demand of the Corn Belt States for all possible protection from the inroads of the corn borer, the first session of the Seventieth Congress passed an act authorizing an appropriation of \$7,000,000 for the conduct of a second control campaign, with the objective of reducing the natural spread of the pest. Under the program proposed by the department for the administration of this act, the work was to have begun in the fall of 1928, but the Congress adjourned without appropriating the necessary funds.

By the terms of the appropriating resolution which failed of passage it was stipulated that adequate regulations be promulgated by all of the States involved and that assurance of the satisfactory enforcement of such regulations be given before the department could begin any work under the act. Therefore, in order to enable the department to function under the recent act in case the next session of Congress should appropriate funds in accordance with the terms of the existing resolution, it will be necessary for the States involved to issue regulations so early that the farmers in the control area may receive adequate warning to enable them, in the fall of 1928, to refrain from sowing small grains in fields that contain cornstalks and stubble. Unless this action is taken, a condition will result which will render the conduct of such a campaign most difficult if not impossible.

The corn-borer research work has progressed most satisfactorily during the year. The concrete results of the investigations on control up to the close of 1926 were published as Technical Bulletin 53 of the department in December, 1927.

The work of introducing the European parasites of the pest has gone forward steadily, and they are being colonized as rapidly as possible in all parts of the affected territory where infestation is sufficient to insure them a fair chance of establishment. Thus far seven species have been recovered,

indicating that they have become established. Department Circular No. 14, reporting on this phase of the work, was published in October, 1927. The general subject of the parasite complex and other controlling factors in the various life zones in central and southern Europe has been discussed in Technical Bulletin 59, issued in April of the present year. The studies of the reactions of the pest to varying environmental conditions and its economic status as regards corn production in Europe, which have been progressing for the past four years, will be concluded at the end of the present growing season. A progress report of these investigations is in press. Additional technical assistance has been furnished the European parasite laboratory, and supplementary funds have been allocated for adequate expansion of the work of parasite introduction and distribution during the coming year.

SUGAR CANE MOTH BORER

The moth borer is one of the limiting factors in the production of sugar cane in Louisiana and constitutes the principal insect problem encountered by that industry. During the spring of 1927 it threatened most serious injury to the valuable P. O. J. varieties of disease-resistant seed cane, and the sugar interests of Louisiana appealed to the department for an allotment of \$50,000 for dusting this and other varieties with sodium fluosilicate in an attempt to insure an adequate supply of dependable seed cane for planting in the recently flooded areas of that State. Although the department realized that negative results might and probably would be obtained, it was felt that the good that might be accomplished should the experiment prove successful would be so great and far-reaching as to justify the expenditure. The request therefore was granted, and arrangements were promptly made to have some 5,000 acres of cane dusted from one to three times by airplane in an efficient and expeditious manner. The results of this work, however, were disappointing. The average net kill was only 20 per cent of the insects, which was far too low for control. It was apparent from this experiment that reliance for control should be placed on other methods, and chiefly on the soaking of the seed cane in water at air temperatures previous to planting—a method which has been determined by departmental experts to be both safe and efficient.

HESSIAN FLY

Estimates made in July placed the loss caused by the Hessian fly in the Kansas wheat crop of 1927 at 20,000,000 bushels. The affected area involved not only southern Kansas but also northern Oklahoma, where heavy losses also occurred. Some reduction of the crops of 1927 by the fly occurred also in Pennsylvania, Maryland, and Virginia. Severe fall injury to the winter wheat crop of 1928 followed, particularly in early planted fields in both the eastern and western regions previously mentioned. In Kansas and Oklahoma spring infestations in 1928 were much modified by weather conditions unfavorable to the fly, but in Pennsylvania, Maryland, and Virginia spring infestation in some localities and early planted fields resulted in lodging and material thinning of the stand.

Coordinated, systematic study of the Hessian fly, its parasites, and its control have been continued. The long-term experiments to determine the optimum time for sowing wheat to escape fall infestation are still in progress. Studies of the comparative fly-resistance of different wheat varieties and the factors responsible are being continued.

MORMON CRICKET

For at least 10 years past the Mormon cricket, which really is a large long-horned grasshopper, has caused the ranchers of the Great Basin, and particularly those of Sanders and Lake Counties, Mont., and of Rout, Rio Blanco, and Moffatt Counties in northwestern Colorado, serious trouble by destroying their forage crops. Some years ago it was determined that these crickets could be poisoned by modifications of the ordinary poisoned baits used for grasshoppers, but owing to the scarcity of water, the cost of the baits, and the inaccessibility of their ingredients, control by these methods was not found generally practicable. Efforts were made by the bureau, therefore, to discover if possible some less expensive and more simple and easily applied remedy which would not involve the use of water. This end seems now to have been achieved in the use of sodium-arsenite or calcium-arsenite dusts, and these have been applied successfully for the control of this pest during the past spring. A large-scale demonstration was arranged with State officials which, it is believed, proved fully the practicality and economy of this method of control.

OVERFLOW WORM

In the summer of 1927, after the subsidence of the flood waters in the Mississippi Basin, there appeared on overflowed lands in the valley of the Black River in Arkansas the larvæ of a cutworm often called the "overflow worm" and known to science as *Agrotis ypsilon* Rott. This was reported to the department, and an expert was dispatched to help in the fight against the pest. The damage had already been done, however, and the worms had largely disappeared before he could reach the scene of the outbreak. In July of the present year a similar outbreak developed, and the Bureau of Entomology was notified in time to permit its expert to act with the farmers and aid in the work of instructing them how to poison the insect. As a result the pest was completely controlled and large acreages of crops were saved.

WHEAT JOINT WORM

Until July, 1926, the wheat joint worm was not known to injure wheat grown west of the Rocky Mountains. At that time, however, a colony of this pest was discovered to be infesting wheat on farms near Malalla, Clackamas County, Oreg., and subsequently a similar infestation of small extent was found near Lebanon, Linn County, in the same State. In view of the fact that in the Eastern States this pest has been known for more than 80 years as one of the most serious enemies of wheat, these infestations have been kept under constant surveillance; and as they are increasing rapidly in intensity a circular of information regarding the wheat joint worm is being issued in cooperation with the Oregon State Experiment Station.

ALFALFA WEEVIL

At this writing the full report of the survey to determine the annual spread of the alfalfa weevil is not available, but the insect has been found in Nebraska for the first time at Henry, Scotts Bluff County. This discovery is important because the insect is now approaching closely to one of the greatest centers of alfalfa production in the country.

The investigation to determine the potentiality of alfalfa-meal mills in the possible distribution of the pest through commerce, which was begun in a tentative way last year, was provided for by action of Congress last winter and has been strengthened by

the appointment of a trained investigator who will devote his entire time to this problem.

The work of introducing the foreign parasites of the pest is being continued.

INVESTIGATIONS OF INSECTS AFFECTING STORED PRODUCTS

E. A. Back has continued in charge of investigations relating to stored-product insects.

DRIED-FRUIT INSECTS

During recent years various troubles which impair the quality of California dried fruits have become increasingly prevalent. The work of the dried-fruit-insect laboratory at Fresno, Calif., for the year has been largely concerned with the problem of reducing damage to figs, not only in storage but also in the field, where much of the trouble begins. During the early part of 1927 a large quantity of the 1926 crop of California figs was so wormy and so infested with molds that many shipments were seized and destroyed under the provision of the food and drug act. When it is understood that an estimated 10 to 12 per cent of the California fig crop was thus removed from the market, the seriousness of the situation can be realized.

During the ripening, drying, and storing of figs much loss is sustained by the growers owing to the prevalence of disease and insect attack. The diseases are known as endosepsis, smut, and souring. Although many have believed that insects play an important part in the spread of the diseases, it was not until the past year that definite proof was obtained that endosepsis is carried and spread by the dried-fruit beetle. What rôle as disease carriers is played by thrips, mites, and vinegar flies has not been determined.

Among the insects particularly destructive to figs are the dried-fruit beetle, vinegar flies, the Indian-meal moth, the fig moth, and the saw-toothed grain beetle. Of these, a careful survey indicates that the saw-toothed grain beetle becomes troublesome only after figs have been in storage for some time. The Indian-meal moth and the fig moth become active pests late in the season in figs stacked in boxes or stored in bulk on ranches, both in ranch buildings and in orchards and dry yards, and continue in the packing houses, where they espe-

cially the Indian-meal moth, surpass the dried-fruit beetle in destructiveness. But during the ripening and drying period no other pest is as important as the dried-fruit beetle, not only because of its rôle as a disease carrier but also because of its capacity to destroy the texture of the figs.

Although considerable attention has been given during the past year to studies of the biology of the fig insects, particularly the dried-fruit beetle, the Indian-meal moth, and the saw-toothed grain beetle, and while many new data are being secured almost daily, the main effort of the bureau experts has been concentrated along the line of practical control. Orchards and packing houses have been inspected in cooperation with owners; trapping experiments in orchards have been undertaken with specially devised traps, to determine if possible a relationship between insect abundance and the prevalence of diseases; fumigable storage bins for packing houses have been invented and installed, and experiments conducted in them that have established beyond question the practicability of safeguarding the crop from insects, once it is properly stored. Tests with various new and promising fumigants have been made. In cooperation with the Bureau of Chemistry and Soils, many analyses of fumigated figs have been obtained to determine what effect, if any, fumigations have upon dried figs. Much time has been given to establish, by inspections of thousands of fig samples, the relative importance of various defects due to insects and diseases in consignments of figs offered for sale by growers.

During the year the work has had the hearty support, financial and otherwise, of the California Dried Fruit Association, and most cordial relationships exist between Federal, State, and county agencies. Several progress reports have been prepared and distributed to fig growers and packers.

FUMIGANTS

Attention has been called in previous reports to the cooperative work being conducted with the Bureau of Chemistry and Soils for the purpose of discovering and testing new fumigants. A nonflammable and nonexplosive fumigant that will not adversely affect food products is much needed. Considerable progress in the investigation has been made during the year. Laboratory tests of over 300 aliphatic compounds have indi-

cated 65 that are lethal to the rice weevil in dosages of less than 6.4 pounds per 1,000 cubic feet. Of these 65 compounds 17 were selected as showing promise of commercial value and were tested on a larger scale. Ethylene oxide and methyl monochloroacetate proved slightly more toxic than carbon disulphide and were lethal to stored-product insects at a dosage of 1 pound to 1,000 cubic feet of space. The ethyl and isopropyl esters of monochloroacetate were only slightly less toxic.

Ethylene dichloride in admixture with carbon tetrachloride in the ratio of 3 parts by volume of the former to 1 of the latter has been found lethal at a dosage of 6 pounds per 1,000 cubic feet. It is a cheap, non-inflammable, and nonhazardous fumigant and is already finding extensive use for the treatment of infested furniture, fabrics, etc. It can not be recommended for the fumigation of certain fatty or oily foodstuffs because of the taste imparted to the treated product.

The isopropyl formate-carbon tetrachloride mixture, although slightly less toxic than ethylene dichloride, is better adapted to the fumigation of foodstuffs.

In general, the compounds showing the greatest toxicity were found in the following classes: Iodides, bromides, mercaptans, thiocyanates, isothiocyanates, disulphides, oxides, epichlorohydrin, halogenated ethers, and formates.

Germination tests with wheat indicated that the chlorides, formates, sulphides, disulphides, thiocyanates, isothiocyanates, and mercaptans, in dosages more than sufficient to kill weevils, do not injure the germination of grain. The iodides, halogenated alcohols, epichlorohydrin, halogenated ethers, oxides, and esters of halogenated fatty acids are injurious to the germination of wheat and should be used with caution.

BEAN WEEVILS

During the 1926 bean harvest of the San Joaquin Valley in California it was found that about 70 per cent of the farmers' consignments of beans grown in San Joaquin, Stanislaus, and Merced Counties were infested with bean weevils upon arrival at the warehouse. In the latter part of 1927 the outlook became so threatening that the Secretary of Agriculture was requested by leading agricultural and civic organizations in the region to establish

a laboratory at Modesto. In response to these requests, the Secretary directed the removal of the bean-weevil laboratory from Alhambra to Modesto, Calif.

County, State, and Federal agencies have been cooperating in a most praiseworthy manner during the year in an endeavor to reduce the infestation of the bean and cowpea crops to a negligible degree by community effort in the destruction of bean-weevil breeding places, both on farms and in bean warehouses.

GRAIN INSECTS

During the latter part of the year a definite beginning was made to further a knowledge of the insects attacking flour and of the methods for controlling pests in milling establishments. For years several controls have become standard in the milling industry, but it is believed that a thorough investigation will develop new practices that will be more effective and more economical.

The work in regard to corn weevils throughout the Gulf Coast States has been conducted as in the previous year. The experiments continue to emphasize the possibility of thoroughly protecting corn in storage from attacks of the weevils. The importance of insect control in corn bins in relation to field infestation, animal feeding, and farm economy can not be overemphasized. Although a number of new fumigants have been used experimentally in corneribs, none superior to carbon disulphide has yet been discovered.

FURNITURE PESTS

The demands upon the department for information regarding furniture pests have continued to grow during the year. When the insect problem is more completely understood it is believed that the present emergency will gradually disappear. The bureau has been very active in the distribution of information to manufacturers, retailers, and householders. The principal pests involved are the clothes moths (*Tineola biselliella* and *Tinea pellionella*) and the tow bugs (*Lasioderma serricorne* and psocids) and the furniture carpet beetle (*Anthrenus vorax*), locally destructive in the District of Columbia.

New devices for the protection of furniture in storage have received much attention. Experiments in fumigating furniture with heat and gases have been continued. The business of

treating furniture for the destruction of insects has continued to grow in all large cities. It is believed that if the recommendations of the department are followed fully 90 per cent of the present losses will be prevented.

Five papers dealing with the practical control of furniture pests have been published during the year.

MOTH-PROOFING SOLUTIONS

A more general use of the so-called moth-proofing solutions has come about during the year, and the work of the department with these solutions has continued. Experiments have demonstrated that the proper application of the best solutions imparts a moth resistance to fabrics that is of practical value. This is true in spite of the fact that the same solutions applied as sprays in a haphazard manner by the average housewife have been proven unreliable. Whatever moth resistance is imparted by solutions appears to be the result of the thorough impregnation of the fabric, preferably before the goods leave the manufacturing plant. Fabrics should be thoroughly immersed in or wet with the solution.

CEDAR CHESTS

The investigation of the value of red-cedar chests as protectors against ravages by clothes moths, under way for several years, was brought to a close during the year with the issuing of a general statement to the public.

Investigations have determined that chests in good condition and made entirely of properly dried three-quarter inch red-cedar heartwood can be depended upon to protect clothing placed in them, provided all of the older moth worms, or larvæ, are removed before the garment is stored. Such chests will not kill the adult moths, the older worms, or the pupæ, nor will they prevent eggs from hatching. However, this is of little importance, for no injury is caused by the moth in the miller, egg, or pupal stage, and ordinarily only eggs or very young larvæ are present when garments are placed in cedar chests. Before storage in the chests the larvæ that are one-half to fully grown should be removed from garments and other susceptible fabrics by brushing, sunning, fumigation, or dry cleaning. The young larvæ that are present at the time of storing or that hatch from the eggs present on the clothing are quickly killed by cedar chests made as above described.

Experiments have demonstrated that clothes moths can complete their entire life cycle in certain veneered chests. Chests containing a back and bottom of solid three-quarter inch red-cedar heartwood, but with ends, front, and top of neutral wood veneered on the inside with one-sixteenth inch cedar have not proved dependable as moth destroyers. Chests should contain at least 70 per cent of red-cedar heartwood in the body proper. Chests made entirely of three-quarter inch red-cedar heartwood, with or without covers of neutral wood, and veneered or stamped on the outside in various hardwoods or patterns to match period furniture can be had. The mere odor of cedar, such as is imparted to chests of drawers, boxes, chests, etc., by thin veneers over neutral woods, is of no practical value.

INVESTIGATIONS OF TROPICAL, SUB-TROPICAL, AND ORNAMENTAL-PLANT INSECTS

The investigations of tropical, sub-tropical, and ornamental-plant insects have been, as formerly, under the direction of A. C. Baker.

NEW LABORATORY QUARTERS

During the year the new laboratory at New Orleans was occupied. This laboratory, equipped with all modern facilities, was made available through the cooperation of the parking commission of New Orleans, which financed its construction. Numerous problems of value to different industries are under investigation at the laboratory. The relative values of different oil sprays for the camphor scale are being worked out, and these oil studies have extended to the work on citrus. Several of the technical phases of the effect of oils on citrus fruits, described later, were handled in New Orleans, although the treatments themselves were made in Florida. The study on the influence of environmental factors on predators, also discussed later, is being made at the New Orleans laboratory, and this laboratory has recently undertaken an investigation of some of the fundamental problems in connection with fumigation with hydrocyanic-acid gas.

In Mexico City excellent laboratory buildings with suitable grounds were provided for the work on the Mexican fruit worm. These laboratories were obtained by reason of the cordial cooperation of the Oficina para Defensa

Agricola. They have been equipped with control apparatus permitting the duplication of known climatic conditions. Although field studies on the fruit worm are being carried on in different sections of Mexico, climatic conditions in these regions differ from those of the fruit regions of the United States. The equipment at these laboratories, however, will permit an exact measurement of the activities of the fruit worm under conditions similar to those of the various American fruit regions into which the insect may be introduced.

INVESTIGATIONS ON CONTROL METHODS

Bulb-insect investigations have provided a new dry treatment for bulb flies in fumigation with calcium cyanide. This is done in specially built fumigation boxes which handle the standard trays used by the growers. The cost of such boxes is relatively low, and the cost of the treatment per ton is about 50 cents, in strong contrast with about \$15, the cost with the vacuum method. This latter method, on account of its greater simplicity, was used instead of the hot-water treatment in localities not infested by nematodes; and the sanction of the new method by the plant quarantine and control administration will permit its use wherever the vacuum method has been in operation.

In connection with the hot-water treatment of bulbs for the bulb fly, a study has been made of the influence of the treatment on the stock. This has had two phases. (1) the effect on planting stock and (2) the effect on forcing stock. Results on the second phase only are available. These show that, under proper conditions of treatment, flower production from the commercial viewpoint has been satisfactory. In order to duplicate commercial conditions, treatments have been made in different parts of the country and the bulbs shipped to Washington for forcing.

Although from the commercial viewpoint results with the hot-water treatment have been good, a careful quantitative study has shown some influence on the flowers. In the daffodil groups, the flowers are consistently though slightly smaller than those from untreated stock, with occasional slight crimping, and in the case of the polyanthus narcissi there is a small decrease in the flowers per spike and in stem length. The effects of the treatment appear to be not in the percentage of flowering, but in the flowers

themselves. These influences show consistently in the analysis of the measurements taken, but would be unobservable to any but the most experienced eye. Under excessive treatment, of course, a heavy crimping of the flowers and other injuries are obvious, but these may be taken as an evidence of treatment under improper conditions.

Studies have been continued on a treatment of date offshoots by heat to rid them of scale infestation. In the method first worked out for such treatment heating to the point of killing the terminal bud was believed to be necessary; this set back the young tree nearly three years. Later investigations, aimed at a margin of safety between the death of the scale and that of the bud, have indicated that the scale can be killed at a temperature around 115° F., whereas the bud is not killed until the temperature reaches about 127°. It is planned to utilize this margin in developing a commercial method and thus save the long setback to the offshoots.

A study of the influence of the usual oil sprays on the maturing of citrus fruits has been completed. Practically all citrus-producing States now demand a standard of maturity before fruit can move in the trade. This test is based on a certain ratio between the total soluble solids and the citric acid. Anything influencing this ratio, therefore, would affect the date at which the fruit might legally be considered mature.

The oil sprays reduce the percentage of total soluble solids in citrus fruits, but the reduction is all brought about shortly after the spray application. At first the decrease in citric acid is delayed by the spray, but later the acid decreases faster than in the unsprayed fruit. When the faster decrease of acid extends over a period of three or more months, the decrease is sufficient to give an increased ratio regardless of the decrease in total soluble solids. The study has therefore shown that if the oils are applied at least three months before fruit is expected to reach the legal ratio, it will be advanced in maturing. If, however, the fruit is sprayed within three months of that time, its maturing is retarded. Even if the spray is applied a month before the fruit normally reaches legal maturity, the date of maturity may be delayed a week. With later applications the delay is much greater. In view of the high prices paid for early fruit and the declining prices as fruit comes on the markets

in increasing quantities, this matter becomes of considerable economic importance. The objects of the study were (1) to determine the influence of the spray, and (2), in case this proved to be important, to work out an economic timing of the applications. Since the sprays do not affect the flavor of the fruit in so far as could be detected, their influence on late varieties may be ignored. With the early varieties, however, the delay caused by spraying may result in heavy losses. Results, therefore, show that where early varieties are to be marketed before December, spraying should be done before July 15 or delayed until after the fruit has been picked. By this procedure insect control can be obtained without interference with the maturing of the early fruit, so it can go on the markets in time for the high prices.

BIOLOGICAL INVESTIGATIONS

Data on the habits of the lesser bulb flies have been obtained. These throw considerable light on the disputed point as to whether the attack on the bulbs by the larvæ is of a parasitic or of a saprophytic nature. Past experiments have appeared to give conflicting results. There are, however, two periods when attack may be expected. During the dry season, when the bulbs have hardened off, results have all been negative. Although a heavy oviposition on the bulbs was observed, the resulting larvæ were unable to penetrate, and infestation therefore resulted only when access was permitted by other agencies. During the moist season, however, the reverse proved to be true, and heavy direct attack occurred. This was in a large measure associated with the going down of the tops when the neck of the bulb became soft before hardening off. Direct attack, therefore, is prevalent when conditions are suitable for such attack.

A study of the developmental history of the narcissus bulb fly has been completed and results published.

Field studies on the susceptibility of the tomato and of pure races of Guatemala avocados to attack by the Mediterranean fruit fly have been conducted in Hawaii. So far as the studies have gone these crops have been proved to be free from attack.

In an attempt to determine the causes of the varying success with predators, a study of the embryonic development and oviposition rate of the Australian ladybird beetle has been

undertaken, special attention being given to the influence of environmental factors on its oviposition and development. An attempt was made to check the causes of wide variations thought to be due to origin or strains from different regions. Thus far the study shows that the variability is independent of the strain and is due to other causes.

A study of the populations of the citrus thrips in California has been continued. Wide fluctuations in the populations from year to year have led to an attempt to plot these fluctuations with the hope of determining their causes.

DEVELOPMENT OF EXPERIMENTAL METHODS

Two experimental methods have been reported on. A modified field method for determining oil in oil emulsions, has been perfected. This employs 20 or 30 cubic centimeters of the emulsion and concentrated acids after the emulsion is discharged.

A method for determining low wind velocities to which the anemometer will not respond was devised and tested. A single-unit Pitot tube was employed with readings on a two-arm horizontal manometer. Two methods were tried, one taking alternate readings on the two arms and the other taking simultaneous readings. Little difference was found in errors by either type of reading.

QUARANTINE AND ERADICATION

The season's work, in cooperation with the Federal Horticultural Board, on the enforcement in Hawaii of the quarantine against the Mediterranean fruit fly and in the Rio Grande Valley of Texas of the quarantine and control work against the Mexican fruit worm, handled by this division from the middle of September until the close of the fiscal year, is reported by the Federal Horticultural Board.

TRUCK-CROP INSECT INVESTIGATIONS

Investigations on insects infesting vegetables and truck crops have been continued under the general direction of J. E. Graf.

MEXICAN BEAN BEETLE

Biological studies on the Mexican bean beetle showed that one generation of the insect developed annually in New Mexico, two in Ohio, and three, with a partial fourth, in Alabama.

The first adult appeared in the field in Alabama on March 31, whereas none were found in Ohio until May 25. The survival of hibernating forms during the winter was rather low in Ohio, varying from a maximum of 1.91 per cent to a minimum of 0.75 per cent. Surveys in southeastern Ohio indicated that there was a distinct gap between generations, with the result that beans planted when the overwintered beetles were becoming scarce escaped heavy infestation. Natural enemies of the bean beetle have not been a factor in the control of this insect in any part of this country, although eggs of a native parasite of the beetle, *Phorocera claripennis*, were found on from 5 to 8 per cent of the Mexican bean-beetle larvæ at Newport, Tenn.

Numerous tests of new insecticides have been made for the control of this insect. As in previous years the best results were obtained by the use of magnesium arsenate or calcium arsenate. Sodium fluosilicate gave good control, but on some occasions caused injury to the plants. Cage tests indicate that pyrethrum extracts are very toxic to the bean beetle, and dilutions five to eight times greater than those used against the Japanese beetle were effective. These extracts did not always give satisfactory control in the field under conditions of heavy infestation, probably because of the lack of residual toxicity and the difficulty of reaching all of the insects.

Studies on climatic conditions favorable to the bean beetle have shown a rather definite correlation between large populations of the beetle and low evaporation, but in determining the exact relationship of these factors the availability of suitable hibernation quarters must be considered. In general, the insect has been more numerous and has done more damage throughout the Southern and Eastern States than in the previous two years. The spread into new territory has been greater than in any previous year. At the present time it is found adjoining the important bean-growing areas in New York and Michigan.

As in former years, the hibernation of the Mexican bean beetle in New Mexico was found to be definitely limited to altitudes at which the yellow pine and oak are found in association. Although the survivals above the range of this association averaged less than 1 per cent, the winter survival within the yellow pine and oak association ranged from 10 to 28 per cent. Below

this zone in the piñon region about 16 per cent of the beetles survived the winter, whereas in the short-grass region of the valleys all of the beetles perished.

SWEET-POTATO WEEVIL

Studies on the control of the sweet-potato weevil have been continued in the States of Mississippi and Alabama in cooperation with State organizations. During the year over 4,500 farms were inspected in the two States concerned. The work in both Mississippi and Alabama has been conducted along the lines followed for the past several years, i. e., scouting work, including inspection in sweet-potato fields, storage banks, seed beds, and shipping sheds. In addition to the regular scouting work, all of the fields on infested properties were thoroughly cleaned at harvest, and in spring the old seed beds on all properties previously known to have been infested were cleaned, and the planting stock was kept under supervision. Careful inspections were made on farms which were near infested properties. The progress in reducing the number of infestations has made it possible to give closer supervision to this work. At the end of the year 12 farms were known to be infested in the counties of Pearl River and Hancock in Mississippi, and 23 farms were known to be infested in the counties of Mobile and Baldwin in Alabama. In Florida and Georgia the Baker-Charlton area was released as free from the weevil, as a thorough inspection within and around the originally infested area did not disclose the presence of weevils. This campaign was initiated in 1919, and 250 farms were found to be infested at one time or another during the experiment. No weevils have been found in this area since 1924.

SWEET-POTATO WIREWORM

A study of root-feeding insects affecting the sweet potato was initiated as a result of numerous complaints of injury to sweet potatoes. It was found that most of this injury resulted from wireworm attack, and on collecting and rearing the insect responsible for the damage it was found to belong to a genus of wireworms new to North America. The life history and habits of this pest are under observation, but it is still too early to indicate the possible life cycle of the insect or to give advice on the most promising methods of control.

SEED-CORN MAGGOT

The seed-corn maggot has been reared through the winter on the eastern coastal section of the Carolinas, but its activity and occurrence during the summer have not been followed. Occasional adults have been trapped during the summer in the vicinity of potato fields, but no information which shows how these insects spend the summer is available. A large brood of larvæ occurs from March to early in April and is responsible for the injury to seed potatoes. The apparent attraction of the adults to spinach seedlings is probably due to the presence of fertilizers near the surface of the soil. Work on remedies has not been completed, but through cooperative studies with the Bureau of Plant Industry the indications are that injury to seed potatoes can be avoided by the application of cultural practices and proper handling of the seed.

Studies on the food requirements of the maggot have shown that the insect is primarily phytophagous, but that the attacked seed must be in a state of germination to render it suitable as food.

SUGAR-BEET LEAF HOPPER

Fundamental studies on the ecology of the sugar-beet leaf hopper have been continued from the previous year. The investigation of the environmental complex will, it is believed, furnish an important working basis for entomologists. Surveys in South Dakota and Idaho were completed during the year, and other surveys now planned include Montana and portions of New Mexico. These will undoubtedly provide a basis for estimating the probable economic distribution of the insect, a most important question to farmers and mill owners. The State of Oregon was carefully surveyed during the past year, but owing to varying conditions there are several details yet to be worked out. It is probable that further studies will indicate localities which may be so safe from severe attack by the leaf hopper as to justify the cultivation of sugar beets. Explorations for parasites have thus far failed to produce promising results. Some parasites have been found in Mexico, but apparently all of these are already established in California. The exploration, however, has served to show that the insect's known range in Mexico extends at least 500 miles south of the border.

The prediction of outbreaks of the insect has been limited, as in the pre-

vious year, to the Twin Falls area in Idaho. At an early date farmers were informed of the great danger attending beet growing there during the present year. The prediction for injury by the leaf hopper was fully borne out in the Twin Falls area before the end of the fiscal year 1928. Indications are that injury to the east of this area will be somewhat heavy, but it will be impossible to predict this injury with assurance before harvest. It appears at this time that the forecast for injury in the Twin Falls area has, through the reduction of plantings, prevented enormous losses, and demands have been made for the extension of this service to areas in eastern Idaho and California.

STRAWBERRY WEEVIL

Studies on the biology of the strawberry weevil in the vicinity of Chadbourn, N. C., showed that the earliest weevils to appear fed on chokeberry buds but did not oviposit within them. The earliest feeding took place on wild hosts, but as soon as the strawberry buds appeared the weevils moved from the woodland to the strawberry fields. From catches on sticky screens placed about the edges of the fields and within woodlands, it was estimated that about 85 per cent of the beetles hibernated in the first 100 feet of woodland adjoining the strawberry fields. The survival of larvæ in cut strawberry buds varied largely with weather conditions and with the type of bud in which oviposition had taken place. The buds which opened on drying were the ones most favorable for the survival of the insect. Only one generation of the beetles appeared during the year. As in previous years the best control was obtained from a mixture of lead arsenate and sulphur.

RASPBERRY APHIDS

Biological studies on three species of raspberry-infesting aphids are being made with reference to the manner and time of transmission of the raspberry mosaics and the various stages during which transmission is possible. Field studies to determine the aphid population throughout the season have also been conducted, but as yet these studies have not shown any particular relationship to the transmission of the disease. Observations on the relative abundance, time of appearance and disappearance, and periods of migration of the raspberry aphids have been particularly considered.

TOBACCO STALK BORER

Heavy injury to tobacco grown as a source of agricultural nicotine in New Mexico and Arizona resulted in the initiation of a part-time study to determine the insect responsible for the injury, and the means of preventing losses. The insect was found to be the tobacco stalk borer; it lives normally on several of the wild nightshades, but subsequent to the planting of tobacco it had transferred its attacks to that crop. Experimental fields, ranging in size from a few acres to 40 acres, were very severely injured, some of them being abandoned. At this time it is impossible to state whether a practical control for the insect will be possible, owing to its wide dissemination on wild hosts, but a study of its life history is being undertaken in the hope that the information thus gained will lead to the development of practical remedies.

CELERY LEAF TYER

Experiments for the control of the celery leaf tyer did not give as successful results as had been expected. The most effective insecticides either exposed the celery to a dangerous arsenical residue, or, in the case of pyrethrum, were expensive and had little residual effect. The latter material was utilized by many of the growers, a choice which undoubtedly resulted in the saving of considerable quantities of celery. Tests with sprays were not promising, on account of the heavy foliage covering the celery rows. Studies to discover an indirect control of the insect were undertaken in cooperation with the plant board of Florida, the board leading in studies of the biology and ecology of the insect and the relation of the growth of the celery plant to infestation by the celery leaf tyer. Studies on parasites and experiments on a small scale in the colonization of egg parasites were undertaken to determine the usefulness of natural enemies. Although no definite results were obtained, the parasitism noted in the field gave hopes that heavy colonization of egg parasites at the proper time might prevent a damaging infestation of the celery. Plans have been made for testing out on a large scale the hibernation of the egg parasites.

PEPPER WEEVIL

The pepper weevil has continued to extend its zone in southern California, and Ventura County was found to be

infested during the year. Infestation was fairly general in the principal pepper districts of southern California. Field infestations were noted July 1 and the first and second settings of peppers were safe from attack before the insects became numerous. Owing to the mild winter the weevils were active and depended on nightshade for food after the disappearance of the pepper plant. The insects were controlled successfully by using from 3 to 11 applications of calcium-arsenate dust. Dusted plots averaged 1,600 pounds of peppers in excess of the checks. Peppers for canning were freed from residual arsenic in the canning process, but it was found necessary, in order to free from dangerous arsenical residues the peppers used for drying, to wash them. Studies are now under way to discover the exact rôle of nightshade as an alternate host of the insect, since information on this factor will indicate the possible value of clean culture. These experiments are being conducted in cooperation with the California experiment station.

BROWN VEGETABLE WEEVIL

Arsenicals have again proved of value against the larvæ of the brown vegetable weevil, but, in order to escape the possible hazard of dangerous arsenical residues, experiments are now under way to develop a poisoned bait which will be effective against the adults. In Mississippi certain dehydrated vegetables properly moistened have proved attractive to the beetles, even in the presence of their food plants, and barium carbonate has shown indications of being a suitable bait poison, since its use for control has given some results which were even superior to those of the arsenicals. Owing to the cost of dehydrated vegetables, an effort is now being made to dilute the bait carrier with such materials as bran and sawdust in an endeavor to reduce its cost. Owing to the aestivation of the adults, the baits, in order to control the insect, must be most attractive before it deposits its eggs. For the first time beetles were found aestivating beneath the bark of trees. Studies for the control of this insect are being initiated in California in cooperation with the California experiment station.

WIREWORMS

In southern California experiments were continued to determine the movement of wireworms in the soil and

their concentration at baits. Although a variety of materials was tested, wheat, beans, and corn proved the most attractive. Wheat apparently was more attractive to the insect than any of the other materials used. Narrow rows of bait (2 feet in width) attracted a considerably higher proportion of the wireworms than did bait rows 3, 4, and 5 feet in width. Dehydrated vegetables soaked in various poisons were tested for lethal efficiency, but no promising results were obtained. The indications were that the poisons repelled the wireworms. The experiments showed plainly that additional information on the biology and habits of the wireworms must be obtained before much progress can be made in controlling them.

In the State of Washington further studies were made on the biology and control of wireworms. Studies were made on the effect of temperature on various stages of the insect, and it was found that development was greatly accelerated under high temperatures (75° to 80° F.). Careful studies on the effect of temperature, moistures, and types of soil on the habits and development of the insects are being made. Tests with fumigants have shown that the use of either calcium cyanide or carbon disulphide is practicable on small, intensively cultivated areas. The carbon disulphide, although expensive, gave excellent results. This material gives promise of extended use in the high-priced trucking districts, where the cost of application is of less importance than freeing the soil of wireworms. Further studies on the hibernation of wireworms showed that the greatest number in hibernation were from 8 to 18 inches below the surface, a distance which was also below the frost line.

COTTON-INSECT INVESTIGATIONS

Investigation of cotton insects have been carried out under the direction of B. R. Coad, as formerly.

COTTON-BOLL WEEVIL

The crop-growing season of 1927 was marked by a general increase in serious depredations by the boll weevil, in contrast with conditions in several years preceding, and was accompanied by a similar increase in interest on the part of farmers in measures for controlling the weevil. Conditions in the earlier part of the season of 1928 were much the same, and it seems evi-

dent that the weevils have returned to a more normal activity than has been the case during the recent years of extreme climatic control. The increased damage is, of course, accompanied by a marked increase in operations for commercial control.

Studies on the hibernation of the weevil have been continued on a broader basis than heretofore, both by the bureau and by the cooperators of the various State experiment stations that are carrying on similar experiments. A number of new points of observation have been added at strategic locations in the South, especially in Georgia and Alabama, and the picture of seasonal activity of the weevil is thus becoming steadily more complete.

In the studies of boll-weevil control at Tallulah less attention has been devoted to the plat type of test and more to strictly fundamental research. The studies of swath width were seriously interrupted by the overflow of 1927, but some additional tests were fitted in on cotton planted late after the water receded and much more definite conclusions are now available on numerous questions relative to problems of swath width with different types of machines and with the adhesion of poison under various conditions. One striking result of this progress has been the definite demonstration of a swath of approximately 15 rows as the maximum in width which can be efficiently treated with any type of machine now available, except the airplane, and the inability of the so-called cloud-drift method to give efficient distribution over the wide areas claimed for it. It had been hoped that it would be possible to recommend an increase in width of swath for the type of machines involving wheel traction, but results show this plan to be impracticable; and it is generally indicated that swath widths can not be increased safely with machines of low nozzle velocity; further, that the greatest hope for success along this line lies with machines of high nozzle velocity, particularly those with air velocities of 100 miles per hour or more.

In conjunction with this study observations have been continued on the technic and usefulness of the newer types of dusting machines, especially those of high nozzle velocity; and the possibilities and capacities of the types now available on the market have been fairly well determined. Obviously there is still room for considerable improvement in this class of dust-

ing machines. At the same time very promising progress is being made in the application of the improved principles of this type of machinery to equipment which is less expensive and of smaller capacity. The development of cotton-dusting attachments for use on cultivators has progressed far enough to show rather definitely the prospects of success, the main problem being the devising of machinery suitable for the wide diversity of types of cultivators utilized in different districts. Machines for use on the riding type of cultivator are now extensively used in field work, and improvements and modifications are being made as suggested by results. A small tractor has been provided, and equipment suitable for use on this class of motorized cultivator is being constructed and tested. Work is also under way on the improvement of the older types of dusting machinery, with special reference to making them suitable for the various dusting compounds they are now called upon to distribute. As a result the technic of dusting is being steadily improved, both as regards ground machinery and as regards airplane dusters. Several new types of airplanes have been equipped and studied in operation, while the equipment previously available has been employed extensively in standardizing and improving the methods of its use. This form of dusting is becoming a considerable factor commercially, as apparently something like 500,000 acres of cotton was dusted by airplane in the United States in 1927, besides the acreage dusted on other crops. So far the indications are that airplane dusting on the 1928 crop will be considerably greater than heretofore.

A new line of experimentation on the boll weevil has been undertaken in South Carolina. For a number of years this division has been studying methods of quickly determining the severity of attack by the weevil, and this work has finally been carried to the point where a reasonable series of observations can be depended on to give reliable information, which in turn may be utilized as a basis for giving advice on weevil control. To advance this work more rapidly a program of cooperation was perfected between the Bureau of Entomology, the South Carolina State experiment station, and the extension service of South Carolina, under which an extensive series of observations is made weekly by bureau representatives and transmitted to the extension authorities so that they may prepare timely

recommendations and give timely advice to the farmer. This type of co-operative research and extension is still in the experimental stage, but it is hoped that with sufficient experience similar to that now being gained it will be possible to organize such a service throughout the more seriously injured areas of the Cotton Belt and thus make possible intelligent weevil control with the maximum chance of success.

A comparatively heavy emergence of the weevil in South Carolina in the spring of 1928 has permitted carrying out some plat tests of early poisoning, to clear up certain points which it has not been possible to work out during the past several years of comparatively light emergence. At the same time the detailed studies of hibernation and emergence have been continued in South Carolina as representing southeastern conditions, and for contrast with the records being made in the Mississippi Delta at Tallulah.

The conditions resulting from flood in 1927, and the consequent total absence of cotton in certain large districts near Tallulah, have offered an unusual opportunity for studying the distribution of weevils entering, and again on emerging from, hibernation. Consequently the studies of weevil flight by use of field screens, which have been conducted in South Carolina for the past several years, have been relocated in the Mississippi Delta and greatly enlarged, so that they include a wide diversity of exposures as regards presence and absence of cotton last year and the abundance or lack of shelter for hibernation. This same series of experiments also includes a general study of habits of weevil movement, and with it has been combined the field testing of attractants which have been developed in the chemotropic experiments to the point where they are attractive on a laboratory basis. The field tests, of course, are the final trial to determine whether or not these materials which are attractive to the weevil in the laboratory can be made of commercial use in the field. One interesting feature of this work so far has been the unexpectedly widespread infestation of cotton by the weevils in the spring of 1928 throughout those areas where there was no cotton in 1927, thus indicating a greater movement of weevils into hibernation, and also a greater movement into the field than has been generally believed to be the case in the past.

Another new organization for control of the boll weevil has been established in the State of Oklahoma, where

climatic conditions were such during 1927 that very unusual damage by the weevil was experienced and where there was great uneasiness as to the probability of a repetition of such damage. Here the work has been twofold: In the first place, stations for plat tests have been established at Synnewood and Durant, where thorough tests of various methods of controlling the weevil which seem to be most promising under conditions prevailing in Oklahoma are being conducted to serve as a basis for future recommendations in that State. In addition, a program of cooperation with the experiment station and with the college and extension workers has been perfected, under which an intensive study is being made of the field activity of weevils throughout the threatened portions of the State, this information being used as a basis for timely advice along much the same plan as that already described for the State of South Carolina. Thus this type of experimental cooperation is in practice under the extremely different conditions of South Carolina and Oklahoma, and it is hoped that this experiment will make possible recommendations for much more effective control of the weevil in the future.

At Tallulah the plat tests are largely devoted to the continuation of the studies on the measure of loss of cotton from different degrees of infestation. These studies have been under way for many years and are most useful after a long series of records has been accumulated. The studies include tests of the most promising of the newer insecticides which have shown sufficient effectiveness in the laboratory and in cage tests to warrant trial in the field. Laboratory and cage tests are being carried on as usual with a long series of chemicals and suggested remedies for the weevil.

COTTON HOPPER

Studies of the cotton hopper have now been rather completely reorganized with considerably less attention to field-plat tests and more to a study of the biology of the insects concerned, as well as fundamental studies of the possibility of transmission of disease in an effort to determine the nature of the disorder caused by these insects. Control studies are under way, and especial attention is being devoted to the problem of the exact nature of the toxic action of sulphur on both the nymphal and adult stages of these insects and their related species. Various outbreaks throughout the Cotton

Belt are being studied wherever possible, and especial attention is being devoted to the causative species, together with their local life history and host plants other than cotton. It now seems possible that while *Psallus seriatus* is generally the causative species for this class of damage in Texas, other species, particularly *Lygus pratensis*, are usually the principal offenders in other territory except possibly in the extreme Southeast, where *Psallus* again becomes the predominant species. Control by dusting with sulphur has usually proved at least fairly satisfactory in the field, but obviously will still stand much improvement, and there are still occasional cases of complete failure of this method to be accounted for and eliminated if possible.

ARIZONA WEEVIL

The Arizona weevil continues to increase in cultivated cotton in the Southwest, and although during the year it has not been found in any areas where it was not previously reported, it has been found more abundant throughout these areas than ever before. In the upper regions of the Santa Cruz River between Nogales and Continental, Ariz., the increase in infestation in cultivated cotton has been particularly marked, and evidently this area is serving as a breeding ground for large numbers of weevils which are infesting cotton fields more remote from natural infestations. Since eradication of the weevil in nature seems hopeless, and since even partial eradication is not feasible at the present time, an effort is being made to develop a means of reducing and holding to a minimum this danger zone, which is producing weevils that constitute a menace to other areas. The biological and other work has indicated the possibility of restricting population by certain field clean-up measures, and several hundred acres of cotton near Tubac, Ariz., has been selected for use as experimental areas in the tests of various repressive measures. The scouting work in the mountains has been practically completed as far as the area infested by weevils is concerned, but it has been found desirable to reopen this investigation in some areas north of Tucson for the purpose of working out the exact distribution of the plant in a slightly overlapping zone where the weevil is not now known to be present but where there is serious possibility of its occurrence. The biological investiga-

tions at an isolated ranch have been continued and show a steady adaptation of this insect to conditions of cotton cultivation. The number of individuals produced in this field each year increases very steadily, and gradual changes in their habits are becoming evident. This study is exceedingly important in determining the exact nature of the future activity of this insect in case it becomes established in cultivated cotton over a long series of years. Several manuscripts have been prepared dealing with the different phases of the problem of the Arizona weevil, particularly with biological studies and studies of the weevil's distribution in nature.

PINK BOLLWORM

Research investigations on the pink bollworm have now been undertaken on an elaborate scale. The first few months of the work were devoted to becoming familiar with the territory and the problem involved. Next, a cooperation with the Texas State Experiment Station was entered into, under which the State and Federal funds are administered jointly, and one organization financed from both sources has undertaken the experimental work. Headquarters are located at El Paso, Tex., with an extensive biological laboratory at Presidio; sublaboratories have been located at Balmorhea and Marfa, Tex., and Tlahualilo, Durango, Mexico, as well as temporary laboratories at other points where the needs of the work justify. There is now under way a complete study of the life history and habits of this species in all of the infested districts. Especial attention is being devoted to hibernation, survival, and emergence, with particular reference to the effect of different cultural practices on winter survival. Furthermore, recent experiments have given strong evidence of the influence of the wind in the spread of this species, and owing to the importance of this problem in connection with proposed eradication or regulatory measures a complete study, from every possible angle, of flight habits is under way. The pink-bollworm studies begin in the Laguna district of Mexico and extend northward as far as the species has been found in the United States.

In connection with the pink-bollworm project cooperative plans have been worked out with the division of agricultural engineering of the Bureau of Public Roads, covering studies of spe-

cial cultural methods for increasing mortality in the winter, and also methods of incineration or other disposal of gin and oil-mill waste which has been shown to be exceedingly dangerous material as providing for the concentration and later spread of the pink bollworm. So far the methods of getting rid of the large accumulations of such dangerous materials have been exceedingly crude. It is hoped that more efficient methods can be devised and some system perfected under which the future accumulation of such nuisances will be prevented.

COTTON BOLLWORM

During the past several years the cotton bollworm or corn earworm has been increasingly injurious in many areas from Alabama westward, and the changed methods of cotton production which have come about since the investigations of this species that were conducted a number of years ago have opened up many new problems regarding the elimination of this damage. Furthermore, definite information on the effectiveness on bollworms of methods for poisoning the boll weevil is seriously needed. For several years the bollworm infestation has been particularly heavy in the vicinity of Bryan, Tex.; this center has therefore been selected as headquarters for special studies on this species, and a series of studies on control, life history, and habits are now under way. The State experiment station of Texas has a similar project, and the work has been so arranged that the results of both Federal and State workers can be combined and correlated.

COTTON LEAF WORM

The cotton leaf worm was decreasingly abundant in 1927, and so far has not been found in the United States in 1928; investigations on this species have therefore dealt largely with an effort to obtain more definite information on the exact location in South America where it breeds up for flight to the United States, and the local conditions which give rise to such flights.

INSECT ACTIVITY IN THE UPPER AIR

Of especial interest during the year have been the studies on insect activity in the upper air. These were started first in the effort to trace the direction of flight of migrating leaf-worm moths, and have included a long

series of releases of small balloons with return tags. These have brought very interesting information on the normal directions of travel of air currents from various districts in the South. At the same time, by the use of insect-collecting traps carried between the wings of airplanes, it was soon found that an unexpectedly large number of insects are present in the upper air, although many of these are insects which possess little or no power of flight and thus are obviously carried involuntarily by air currents. These facts are so important in connection with the various questions of spread and movement of different cotton insects that a very extensive series of records has been inaugurated and will be carried out through different districts. So far it seems that the stronger fliers, although influenced to a certain extent in their directions of travel by the air currents, are able to confine themselves to comparatively low altitudes and have rather definite control over their directions of flight; the weaker fliers, however, are not so successful in offsetting air currents and apparently many of them are carried as absolutely by these currents as if they had no will in the matter. Species which have never before been suspected as possibly being wind borne have been caught at great elevations, and since these observations were begun other types of records have been made on several cotton insects, particularly the pink bollworm and cotton hopper; and there is every indication that wind transportation may be a very important factor in their spread. Extensive observations are being made to check up on these points.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

This work has been continued under direction of F. C. Bishopp, as formerly. In order the better to administer this developing and important line of research, headquarters were transferred from Dallas, Tex., to Washington, D. C., late in the fall of 1927.

SCREW WORM

Investigations relating to the screw worm and other blowflies which attack livestock have been continued along lines similar to those of last year. Further studies of the efficacy of various baits for use in trapping these flies and of the methods of preventing the breeding of flies in the materials used for baits have been

conducted. This work has shown clearly the importance of preventing the bait pans from becoming dry at any time and has also demonstrated that the period of effectiveness of meat baits may be greatly lengthened if a proper condition of moisture is maintained.

Large-scale tests of fly trapping under range conditions have been continued in cooperation with the Texas Agricultural Experiment Station, and further information has been obtained indicating that where trapping is properly done a material reduction of the number of screw-worm cases in livestock may be expected. It was found that the efficacy of certain traps was lowered greatly by the entrance into them of great numbers of tumblebugs. In other cases lizards, and in still other cases wrens, were found to enter the traps very frequently. Experiments indicate that these invaders can be excluded without decreasing the number of flies caught by placing wire of one-quarter inch mesh around the base of the traps.

CATTLE GRUBS

The experiments in cattle-grub control, begun two years ago in cooperation with the Virginia Agricultural Experiment Station in the valley known as Burkes Garden, Va., were continued. Although most of the stock owners in the valley reported marked benefits from the work of the previous year, a moderate infestation of grubs was still to be found in local animals. The facts that this work was done by the farmers on a purely voluntary basis and that a great many infested animals were brought into the valley during the season when the grubs were maturing and leaving the hosts are undoubtedly responsible for the failure to eliminate the pests more rapidly from the area under treatment. Further experimental work was done on the application of insecticides in powdered form to the backs of cattle infested with grubs. These experiments demonstrated the value under practical conditions of natural tobacco dusts of high nicotine content when applied to the backs of cattle. Much work along this line still remains to be done.

FLY CONTROL UNDER FARM CONDITIONS

The various procedures in connection with control of flies under conditions prevailing on farms were given further tests in cooperation with the Bureau of Dairy Industry on the Beltsville, Md., farm of the department. Home-

made pyrethrum-kerosene extract used as a spray was shown to be very effective in controlling the horn fly. Although the stable fly and the house fly were reduced in numbers, the inefficacy of fly sprays, except when used in conjunction with every known method of preventing fly breeding, was fully demonstrated.

SHEEP-SCAB MITE AND GOAT LOUSE

Studies of the biology, host relationships, and longevity under varying conditions of the common sheep scab mite and several species of goat lice were continued in cooperation with substation No. 14 of the Texas Agricultural Experiment Station and at the Dallas, Tex., laboratory.

CREeping ERUPTION OF MAN

The investigational work relating to creeping eruption, which has been under way during the past few years, has been brought to a close. Further valuable information has been gained regarding the distribution of the parasite and the disease produced by it, and the ways of differentiating this particular type of eruption from that caused by the larvæ of certain insects. The results of these investigations are being made available to the medical profession and others interested by a series of papers published in medical journals.

MOSQUITOES

Investigations of the biology and habits of malaria mosquitoes were continued at Mound, La., under the direction of W. V. King. Special studies of the ecology of malaria mosquitoes were continued in the Delta region of northeastern Louisiana. These studies dealt in some detail with the food requirements of the larvæ and the relation of various plankton groups to local abundance. Further experiments have been carried out with sprays designed to kill and repel mosquitoes, and investigations of ways of making Paris green more effective in the destruction of the larvæ have been continued.

INVESTIGATIONS OF INSECTS AFFECTING FOREST AND SHADE TREES

This work has been continued under the direction of F. C. Craighead, as in former years.

PINE BARK BEETLES

Heavy increases during 1927 of the losses caused by the western pine beetle in the commercial stands of Oregon and California have emphasized the necessity for working out a better understanding of the natural factors that cause these periodic epidemics. Investigations on this problem were enlarged and concentrated during the season of 1927 on the Sierra and Modoc National Forests of California. Likewise the survey of 34 check plots on the southern Oregon-northern California pine-beetle control project, totaling nearly 20,000 acres, was carried out again during the past summer in order that the cycles of the western pine-beetle infestation in these virgin forests might be followed. Many valuable data were obtained as to the class of trees selected by the beetle for attack, the types and sites of greater susceptibility, and the meteorological conditions which influence the seasonal abundance of the beetles. On the Modoc National Forest large sample plots have been established to determine the site and the quality of timber most susceptible to these outbreaks. It has been found, in general, that stands in which there is a high percentage of individual trees which are slow growing are the most susceptible to these losses. The resistance of individual trees to attacks of the beetle has been studied by means of caging beetles and artificially inducing the attack. Through this method a better understanding of the character of resistant trees has been gained. It is proposed to apply this information in the selection of trees that are to be left on logging areas for seed production and cover. The results of these studies indicate that selective logging, by removing the susceptible and leaving the resistant trees, will materially reduce the losses caused by this beetle in the more mature stands of timber. Two small sample areas in Modoc County have been marked and logged experimentally with this object in view.

A study of the effect of predators and other enemies of the western pine beetle was continued. The past season's results show that several predators are important in the natural control of the western pine beetle and indicate that improvements in artificial control can be so timed that the greatest possible service from these beneficial insects will be secured.

Several years of investigation on windfalls that arise unexpectedly in the forest and induce bark-beetle outbreaks were completed in 1927. Records have been kept since 1921 from two areas of storm-felled trees in California which show that windfalls are often followed by severe but short-lived bark-beetle outbreaks in the surrounding standing timber. Often more timber is killed by the resulting bark-beetle epidemics than is destroyed by the original storm.

Investigations of the broader aspects of the biology of *Dendroctonus monticolae* in lodgepole pine were continued during the past season on the east fork of the Bitterroot River in Montana. The objects of these studies are similar in a way to those described above, namely, to obtain more definite information relative to the factors which may contribute toward the rise and fall of epidemics, and information leading to more economical methods of control. Various methods of artificial control were tested on an experimental basis, some of which show promise of being economically feasible. These consisted principally of felling, girdling, and otherwise treating the infested trees shortly after attack. Information was obtained on the habits and development of these insects, the extent of their flight, and the ratio of beetles attacking the trees to those emerging; and some of this has found ready application in the large control project now being conducted on this same infestation.

AIRPLANE SURVEYS

In connection with the Modoc epidemic and in cooperation with the Forest Service, an airplane survey of the infested areas was made in the fall of 1927. There has been considerable progress in the adaptation of aerial photographic methods to the needs of insect-reconnaissance work.

PROBLEMS UNDER INVESTIGATION IN SOME OF THE STATES

Cooperation with several of the forest experiment stations on insect problems having a direct bearing on forest management has continued on about the same basis as in previous years. Unfortunately it has not been possible to extend the bureau's services in this respect or to meet the demands for enlarging the work of this character.

Interest in the growing of larch in the Lake States has centered atten-

tion on the larch sawfly. The observed fluctuation in the abundance of this insect from year to year led to certain experiments to determine the causes influencing survival and mortality of the hibernating cocoons. It was found that the sawfly is best able to pass the winter in the sphagnum moss characteristic of the swamp forest, while on higher ground greater mortality occurs. Certain biotic factors, as parasites, fungi, and small mammals, were also of importance in lowering the percentage of survival. Of these mice and shrews were found to destroy from 50 to 80 per cent of the hibernating cocoons. It would appear from results of this preliminary work that superficial drainage of hemlock swamps offers a possible means of reducing the probability of outbreaks by the larch sawfly.

At Halsey, Nebr., the introduction of parasites was continued in an attempt to check the tip-moth infestation in Forest Service plantations. Collections were made from the vicinity of Flagstaff, Ariz., in the hope of obtaining species more effective on western yellow pine. Of those liberated previously, one (*Campoplex frustanae* Cushman) has already become established.

In the New England States the program of investigation outlined several years ago for studies relating to the white-pine weevil has been nearly completed. The results have confirmed observations of earlier workers showing that under forest conditions practically satisfactory weevil control can be obtained through appropriate silvicultural practices.

Following the exceptional drought of 1925 in certain portions of the piedmont region, several outbreaks of the hickory bark beetle developed. This insect is rarely destructive so far south. At the present time, following normal precipitation in 1927, these outbreaks have all subsided.

A limited amount of work has been conducted at Starke, Fla., in cooperation with the Southern Forest Experiment Station, on the turpentine borer. This beetle causes a high percentage of cull in lumber sawn from turpentine trees and is likewise instrumental in so weakening the turpentine trees that they are readily subject to wind-throw. It has been demonstrated that on experimental plots of the Forest Service all damage by this insect can be prevented by the adoption of conservative practices, such as the

standard Forest Service regulations, in turpentine operations. The results of several of these studies have been described in publications.

INSECT PROBLEMS IN THE NATIONAL PARKS

During the year practically all serious epidemics which have been mentioned in the annual report for 1927 have come under complete control; in general, therefore, the insect situation on the national parks is very good. The only serious situation which now exists is that on the Rocky Mountain National Park, where control against the Black Hills beetle is being conducted under the bureau's supervision. Funds are available to treat all the infested timber, and it is hoped that no further work will be needed next year.

STATUS OF THE MORE IMPORTANT BARK-BEETLE EPIDEMICS AND CONTROL PROJECTS

The Big Hole Basin control project of Montana, which was instituted in 1926, was continued during the season of 1927. The purpose of this project is to prevent through direct control measures the spread of an epidemic of the mountain pine beetle, which is threatening valuable lodgepole pine stands to the south. In combating this epidemic the Big Hole Basin was selected as a zone of defense, as it lies across the head of the infestation. A few miles to the north and across the Continental Divide to the west this epidemic exists in solid blocks of infested trees, which cover an area of many square miles. This year's work will probably demonstrate whether with limited funds capable of treating only the advance infestation it is practical to continue the attempt at checking the spread of this epidemic.

In cooperation with the Forest Service and private timber owners who contributed to the expenses of the work a survey was made of a heavily infested district on the Modoc National Forest in California. On this district during the past few years the losses have increased tremendously, until in 1927 a loss of 184,000,000 board feet, representing about 3.26 per cent of the pine stumpage in 430,000 acres, was sustained. The timber owners and community have become aroused over the seriousness of the situation and are working with the Bureau of Entomology and the Forest Service to devise some means of remedying the situation. The expense of direct control on a project of such magnitude would be enormous, and it is hoped, therefore,

that a plan involving utilization of the timber will be practical.

INSECTS AFFECTING FOREST PRODUCTS

Many additional preservative treatments for the protection of wood in contact with the ground have been tried in the experimental plots on Barro Colorado Island, Panama, during 1927. As a supplement to these tests of wood preservatives, model, or demonstration, termite-proof buildings have recently been constructed in Panama, these being built entirely of timber impregnated with standard chemical preservatives or constructed of termite-resistant woods grown in the United States. These tests are conducted by the Bureau of Entomology in cooperation with the Forest Products Laboratory of the Forest Service, the Chemical Warfare Service, the Bureau of Standards, and several public-service corporations. Additional tests of mortars of various composition were made in masonry foundation walls erected for the purpose. These are designed to determine the proportions and chemical constituents of the mortars most effective in preventing passage of termites through them.

During 1927 the Pacific Coast Building Officials' Conference adopted certain provisions which were recommended by the Bureau of Entomology for inclusion in mandatory building codes, to prevent damage by termites to buildings. The Territory of Hawaii is likewise considering similar provisions, which, however, will be slightly more inclusive than those recommended for continental United States. These provisions should add not more than 2 per cent to the initial cost of the building, and they should constitute a form of insurance either to the owner or to the person financing the structure.

During the early summer of 1928 the Forest Products Laboratory of the Forest Service initiated a mill study which will be conducted on logging operations in the southern Appalachians. The Bureau of Entomology is cooperating in this investigation in an effort to determine the amount and extent and the resulting loss in grade of the more common defects due to insects in the living timber of this region.

INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS

Activities relating to insects which attack shade trees and hardy shrubs have consisted principally of the han-

dling of inquiries and correspondence. These communications continue to come to the bureau in great abundance, evidencing an important interest in this subject.

Experimental work on the control of the boxwood leaf miner by fumigation with hydrocyanic-acid gas has been actively continued in cooperation with the Pennsylvania State Department of Agriculture, and much attention has been given to examining, advising, and supervising control of infestations by the boxwood leaf miner about Washington, D. C., especially on public grounds. The details of the methods of fumigation and the other means for controlling this species which have been worked out in the course of these investigations are being prepared for publication.

BEE-CULTURE INVESTIGATIONS

The work of the bee culture laboratory has continued under the direction of James I. Hambleton, with headquarters at Somerset, Md.

BEHAVIOR OF BEES

A comparative study of the seasonal brood-rearing activity with the various races of bees has been continued, and one paper dealing with the brood-rearing activity of the Cyprian race has been published outside the department. Computations of the data collected on package bees during 1927 have been made, and a paper on this subject will shortly be ready for publication. Continued tests have shown that the artificial insemination of queen bees is practicable from the standpoint of genetics, and an endeavor is being made to refine the technic now in use. Along with this work, a biometric study of the various races has been undertaken to determine their distinguishing physical characteristics other than color, and also to afford a means of identifying various racial strains desirable for breeding purposes.

The work on the reactions of honeybees to light has been continued, and three main facts have been ascertained as follows: (1) The relative stimulating efficiency of the various regions of the visible spectrum has been worked out, and may be plotted as a curve which corresponds somewhat to the curve for the human eye in that the yellow-green is the most efficient, but differs from the latter in that red is less efficient and violet more efficient; (2) data so far secured indicate that bees can distinguish intensities of

white light that differ as much as 1:4, but can not distinguish differences as small as 1:1.3; and (3) that bees are able to differentiate certain colors from one another on the basis of the quality (chroma) of the color and not its quantity (brilliance) alone and that the number of chromas differentiable by bees is probably at least six, namely, ultra-violet, violet, blue, blue-green, green, and red.

In experiments dealing with the flight activity of bees two new instruments have been developed which make it possible to record quantitatively the amount of flight indulged in by bees when they are free to fly under natural conditions. One of the instruments is so designed that it makes a continuous pen record of flight activity. It is hoped through the use of these instruments to obtain data relative to the effect of various weather factors upon flight activity without the interference of the stimulus to fly caused by the presence of nectar in the field. Coefficients of correlation dealing with the effect of weather factors upon flight activity have been computed.

PHYSIOLOGY OF BEES

The study of the mortality of adult bees during the winter months has been continued, daily records being kept of the deaths occurring in a number of colonies. The effects of weather factors, age of bees, and stores have been given particular attention. Because of the enormous winter losses sustained annually throughout the United States, a loss roughly estimated close to \$8,000,000, this problem is deemed a most important one.

Cage tests on the longevity of adult bees during the active season were carried out. This included the effect upon longevity of feeding with various sugar sirups and queen-cage candies, and of differing environmental conditions.

Serious losses have been experienced in connection with importations of adult bees from Europe, involving both the queens and accompanying worker bees. Work is under way to develop methods which will reduce such losses, the results of which should be of value to our own package-bee and queen-rearing industry.

Experiments are in progress to determine just how the application of heat affects the color of honey and to determine to what extent honey may be heated to retard granulation in

commercial practice and still not destroy the diastatic enzymes. The effects of age and sunlight upon color changes of honey are also being given attention.

DISEASES OF BEES

Eight hundred and fifteen samples of brood and adult bees have been examined for diseases during the year. Regular routine analyses for the following bee diseases are now being made: American foul brood, European foul brood, sac brood, *Nosema* disease, septicemia, mycosis, Amoeba disease, and Isle of Wight disease. A new disease of adult bees caused by a heretofore unrecognized organism, *Bacillus apisepcticus*, was found in the apiary of the bee culture laboratory. A preliminary report on this disease was published outside the department. Altogether 24 samples of bees showing this disease have been sent to the laboratory. These cases were well scattered over the United States, indicating that the disease is quite prevalent, although nothing can be said at this time as to how serious it may be. A disease of recently emerged adult bees, which reached the nature of an epidemic among day-old bees, was also discovered during the year, the causative organism having been determined as *Mucor hiemalis*. The practicability of using formaldehyde gas to disinfect American foul-brood combs is being determined in a large series of tests. If this method of treating combs is found efficacious it should prove to be considerably less expensive than methods now employed to disinfect infected material.

The parasite of adult bees *Acarapis woodi*, prevalent in Europe, has not been detected in any of the importations from foreign countries received during the year, and no indications have been found that this parasite occurs in the United States.

BEEKEEPING REGIONS IN THE UNITED STATES

A series of important studies dealing with the cost of honey production and methods of apiary management was started this spring in the intermountain States in cooperation with the Bureau of Agricultural Economics and the beekeeping specialists in the States where the studies are being conducted. Under the supervision of two representatives of this department—one from this bureau and one from the Bureau of Agricultural Economics—daily labor records are being

kept in about 50 large commercial apiaries. Close attention is also being given to methods of apiary management and honey-house equipment. Honey marketing has made little advance in recent years, and in order that beekeepers may hold their own in the competitive marketing field it is necessary to have a reliable basis of estimating the cost of production under modern methods and with modern equipment.

Because of the widespread belief that honey is not altogether a natural food but has been subjected to a manufacturing process before it is placed on the market, and because of the scant knowledge possessed by the average consumer concerning different flavors, colors, and types of honey, a four-color educational poster has been prepared as a guide to honey consumers.

INTERMOUNTAIN BEEKEEPING METHODS

An experimental apiary consisting of 50 colonies of bees and 30 nuclei has been established at Laramie, Wyo. In this apiary experiments dealing with the spread of infectious bee diseases have been continued, the work being confined largely to determining the minimum number of spores of *Bacillus larvæ* that would establish disease. It was found that as low as 750 spores per cubic centimeter when fed in a suspension of sugar sirup would cause disease in experimental colonies. A method is being devised to determine the spore content of honey so that the necessity for treating supers and other accessory parts of the hive and honey-house equipment may be determined, and also to ascertain what part commercial shipments of honey play in the dissemination of bee diseases.

Apiaries at Fort Collins, Colo., Laramie and Lander, Wyo., and Fromberg, Mont., have been selected for studying methods of wintering, three different methods being used at each place. This year's results at the Laramie apiary seem to point to granulated honey as being one of the prime causes of spring dwindling.

A section of the Penrose bad lands east of Powell, Wyo., was selected for continuing-flight experiments which were started last year. Early results indicate that bees will fly at least 7 miles in one direction to obtain nectar if forced to do so. It is not economical, however, for a beekeeper to locate his apiaries so far from the source of nectar.

INSECT-PEST SURVEY

The work of the insect-pest survey has been carried on, as in the past, under the direction of J. A. Hyslop.

The survey has now functioned for seven years and is recognized as one of the important cooperative activities of the bureau with the agencies concerned in applied entomology in the several States.

By an informal arrangement with a survey in Canada, instituted a few years after the United States insect-pest survey was inaugurated, the bureau survey receives notes on current insect conditions in the Dominion. Last year the Hawaiian Sugar Planters' Association and the Ernest Pauahi Bishop Museum started an insect-pest survey of the Pacific, and, through the courtesy of the Hawaiian Entomological Society, exchanges of outstanding entomological features with that survey are made.

A new project was inaugurated during the year, that of cross-indexing the entire survey records under the host-plant names. So far there have been thus indexed only two-fifths of the American records, but the work already covers more than 400 genera of plants, including over 500 species, with their insect enemies.

During the year the survey completed volume 7 of its monthly bulletin, consisting of 10 numbers, 399 pages of text, and 44 pages of index, and also completed the first 4 numbers of volume 8, comprising 134 pages of text material.

TAXONOMIC INVESTIGATIONS

The work on the identification and classification of insects has continued under the general supervision of S. A. Rohwer. Inasmuch as Mr. Rohwer has had to devote so much time to general administrative work, more detailed supervision has been under the direction of Harold Morrison since August, 1927.

As has long been the practice, the taxonomic work has been conducted in cooperation with the United States National Museum, the specialists of the bureau being given desk room and access to the extensive collections of the Museum. Because of the large number of insects which are received for identification from workers of the department and its cooperating agencies, this cooperation is essential and economical. It gives the specialists access to extensive reference collections

and does away with the necessity, which otherwise would occur, for the bureau to maintain its own reference collection.

The work done by the specialists employed under this unit is primarily in the nature of a service, and consists in furnishing authentic identifications to field workers, thus making it possible for them to have access to the work done by previous investigators. In order that the identifications furnished by this unit may be properly made and based on the most up-to-date information, it is very important that investigations be conducted on the taxonomy of the groups which are most important to American agriculture. The service requested of the specialists in this unit has been so pressing and of such volume that there has not been sufficient opportunity for them to conduct the necessary research. An effort should be made to increase the personnel so that the specialists will have the time to conduct the research necessary to enable them to furnish the up-to-date information required. This expansion is highly desirable, because if the species belonging to any unit are properly classified and the information concerning them coordinated, identifications can be made much more promptly.

During the year 12,074 identifications have been made for various offices of the bureau and department and for collaborators. A very large percentage of these identifications has consisted of specimens referred to the bureau by the inspectors connected with the Federal Horticultural Board.

In the following tabulation the numbers of identifications made during the last two fiscal years are compared:

Orders	Identifications, 1926-27	Identifications, 1927-28
Hymenoptera.....	2,736	1,742
Coleoptera.....	3,329	2,880
Lepidoptera.....	1,694	2,662
Diptera.....	2,333	1,706
Orthoptera and Neuroptera..	620	577
Ectoparasites and small orders	908	864
Hemiptera.....	443	607
Isoptera.....	16	-----
Coccidae.....	(¹)	2,200
Total.....	12,079	13,238

¹ Coccidae not reported in 1927.

In addition to the furnishing of identifications, the specialists in this unit have rendered assistance to research workers throughout the United

States and to their colleagues in foreign countries, and have supplied information concerning the distribution and host relationships of economic insects.

During the year the work has been rearranged, and seven projects have been established. These projects bring together the identification work done on some of the more important economic groups of insects. The projects established are the following:

1. Coleoptera—beetles, weevils, etc.
2. Lepidoptera—moths and butterflies.
3. Diptera—two-winged flies.
4. Hymenoptera—chalcid flies, ichneumon flies, wasps, bees, ants, etc.
5. Orthoptera—crickets, grasshoppers, locusts, etc.
6. Ectoparasites and mites—lice, fleas, etc.
7. Coccidae—scale insects.

In addition to the identification-service work, which is common to all of the projects, certain investigations have been conducted on these projects, of which only a few of the more important ones are given in the following summary:

COLEOPTERA

A revision of the flat-headed borers belonging to the genus *Agrilus* has been completed. Studies have been conducted on the larvæ of the Chrysomelidae, the group to which the Colorado potato beetle and the cucumber beetles belong. A revision of the genus *Trichobaris*, a group of weevils containing such economic forms as those which bore in stalks of tobacco and related plants, has been completed. Considerable progress has been made in coordinating the taxonomic information relating to predacious forms belonging to the families Cleridae and Coccinellidae.

LEPIDOPTERA

Considerable progress has been made toward the completion of a monographic paper on the moth family Tortricidae, which includes many forms of considerable economic importance, such as the codling moth and oriental fruit moth. Much progress has been made in arranging the collections and bringing together necessary information on the larvæ of all lepidopterous insects (butterflies and moths).

DIPTERA

A paper is in preparation setting forth the characters by which the vari-

ous forms of fruit flies likely to be introduced into the United States may be recognized in both larval and adult stages.

HYMENOPTERA

The work done under this project this year has been somewhat hampered by the fact that Mr. Rohwer has been unable to do the work previously conducted by him, and because two of the leaders have been away from headquarters for extended periods. One of these investigators, A. B. Gahan, spent a considerable time in Europe examining collections in foreign museums.

ECTOPARASITES AND MITES

Considerable progress has been made on a catalogue of the North American mites. Investigations on scorpions and fleas have progressed satisfactorily, and an extensive paper dealing with those mites which are injurious to animals is in the hands of the publication office.

COCCIDAE

Some progress has been made in studying the extensive collection of scale insects formed by one of the foremost investigators, Maskell, which had been forwarded for restudy by specialists.

C. F. BAKER COLLECTION

During the year, through the bequest of C. F. Baker, who died in the Philippines, the National Museum came into possession of the extensive collection of insects which he had formed during his long stay in the Orient. This collection contained representatives of many species which were not available to the bureau specialists, and many of these are of considerable economic importance, some of them being hosts of the parasites of such pests as the Japanese beetle and the European corn borer. One of the bureau specialists, R. A. Cushman, working in close cooperation with the museum, went to the Philippines to arrange for the packing and shipment of this very valuable collection. The collection has been safely transferred to Washington and is now available to all of the bureau specialists. It should assist materially in the identification of the specimens which are submitted by investigators in the Orient or intercepted on products coming from there.

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REPORT OF THE CHIEF OF THE OFFICE OF EXPERIMENT STATIONS

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.,

September 15, 1928.

The Hon. W. M. Jardine,

Secretary of Agriculture.

Dear Mr. Secretary:

I have the honor to transmit herewith a report of the work of the Office of Experiment Stations for the fiscal year ending June 30, 1928.

Respectfully submitted,



Chief,

Office of Experiment Stations.

The Office of Experiment Stations continued as in previous years to administer the Federal funds provided for the State experiment stations by the Hatch, Adams, and Furnell Acts; to supervise and direct the work of the agricultural experiment stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands; to review the progress and summarize the results of research in agriculture and home economics in Experiment Station Record; and in other ways to promote and coordinate the work of the experiment stations and similar institutions.

ADMINISTRATION OF FUNDS

The total funds available for station support increased during the year to approximately \$13,500,000, of which \$3,360,000 was from Federal sources and the remainder from State sources.

The Federal appropriations reached \$70,000 for each State. This was an increase of \$10,000 to each State over the preceding year, arising from the Purnell Act, or a total of \$480,000 for the country as a whole.

The appropriations for the support of experiment stations in Alaska and the insular possessions, conducted under the supervision of this office, amounted to a total of \$237,640, and constituted the main support of those stations. During the year Congress authorized the extension of the experiment station Federal funds to the Territory of Hawaii beginning in the fiscal year 1930, with an initial appropriation of \$15,000 and increasing by steady stages. The station is to be conducted in cooperation with the Federal station maintained on the Islands.

As in the past, the Federal appropriations for experiment stations in the States were very liberally supplemented from local sources, mainly by direct appropriations or allotments. This has enabled most of the stations to expand their work and influence quite materially, and has provided improved facilities in the way of buildings, land, and general equipment. There has been improvement also in organization and in the strengthening of the station personnel. Men and women in the lower ranks of the station staffs have been encouraged to prepare themselves more adequately by advanced graduate study, and in numerous cases special opportunities to that end have been opened through the granting of accumulated leave or the opportunity to transfer special projects to the institutions where they were studying.

The Federal funds and the work under them have been administered in considerable detail. New proposals for research projects have been scrutinized closely with reference to the clarity of the aim and purpose, the relation of the proposed experiments and investigations to those carried on elsewhere and to the general status of information, and with particular attention to the means to be employed. These new projects represent great diversity. The specialists included in the organization of the office and their contact with the literature and with the projects in progress, enables such an examination to be carried out, with frequent opportunity for suggestions and references to similar work elsewhere. In order that the office specialists may be better prepared for this service, opportunity is being given them to study more intimately at first hand the research in their several lines by visits to certain of the stations and participation in various meetings, conferences, and the like.

In connection with its administrative supervision of the Federal funds granted to the State stations, an annual examination was made of the work and expenditures at each of the stations, with conferences on special lines of work in progress and on matters relating to plans and general policies.

SUSPENSION OF FEDERAL FUNDS

In three cases certification of stations to receive the Federal appropriations was temporarily withheld during the year. In one of these the action arose from delay of the station in presenting an acceptable financial report for 1927, as required by law, which made it necessary to withhold the certification for the last quarter of 1928 until the matter of balances could be determined. Certification was made upon the receipt and approval of the adjusted financial report.

In another case question arose at the time of the annual inspection regarding the legitimacy of certain expenditures in the previous year and the plans for the current year to relieve the situation. Progress was so slow and unsatisfactory, after several months, that certification for the third quarter was temporarily withheld. Ultimately the plans were revised so that they could be approved, the basis of expenditure was agreed upon, and, with a disallowance of approximately \$3,000 in the previous year's accounts, the funds were restored less the amount disapproved.

In the third case certification was withheld in June, 1928, because of unwarranted action in dropping important members of the station staff, which seriously disturbed the security of position and endangered the continuity of projects in which the Federal funds were involved. Such inconsiderate interference with the welfare of the station and its work had been so frequent in the past and its effects were so demoralizing that the station was not considered a safe custodian of research funds until effective safeguards were provided to insure security and stability. Dismissed members were reinstated as far as they were still available, and a strong resolution was passed committing the institution to a strict policy of merit and accomplishment in reference to tenure of office and providing against summary dismissal. There was delay, however, in filling the vacant positions and completing plans for the new fiscal year, and at the time of writing, the funds had not been restored.

INCREASED RESPONSIBILITIES

With increasing financial support and the stimulus of steadily growing interest and confidence in scientific research as a means of bettering farm life, the stations are enlarging the scope of their activities and multiplying the demands upon the Office for aid in formulating and carrying out effective research programs. The duties and responsibilities of the office are being broadened and made more exacting by the growth of the work of the stations, the Department of Agriculture, and similar research institutions. The field for the exercise of a helpful influence in the promotion of research in agriculture and home economics is a wide and varied one and taxes to the full the present resources of the office.

As time passes it is becoming clearer what is involved in the rapid enlargement of research in many diverse lines if it is to be made highly effective. In some of the newer lines the subjects have not yet been very definitely organized from the research standpoint, and there is lack of background in accepted technique and in research point of view. A deficiency in the number of persons who have had the necessary training and experience to give reliance in independent research makes the setting up and organization of new projects a matter calling for unusual attention.

Progress in the older subjects has made research in them increasingly technical, with consequent difficulty in keeping abreast of the field and making new inquiries progressive. Prevalence of the limited view of what is practical and failure to advance with the progress of investigation in some of the more common fields of experiment has necessitated much attention to bring the work on a higher plane, and has resulted, in some instances, in the rejection of proposed undertakings. Uncalled for repetition and the making of purely comparative experiments in the nature of local demonstrations have been systematically discouraged.

While these conditions are not to be regarded as discouraging, they are recognized as calling for systematic attention if research is to grow in accordance with the opportunity for it. Improvement is steadily noticed, but the amount of reliance placed upon the office for advice and assistance, for participation in conferences, and for analysis and criticism in the various lines of effort has added very greatly to the duties of supervision of the Federal funds for the experiment stations.

The fine spirit in which the services of the office have been accepted by station authorities has led to increasing expectation of leadership in presenting and maintaining standards and in critical survey of the progress and needs in the respective lines. The three years under the increasing Federal appropriation for experiment stations has made clear the opportunity and the need for functions which such a central agency can discharge; but the period has not brought adequate provision for it. Additional specialists and funds for travel are imperatively needed to study, for the benefit of the whole, the essentials of progress of this unparalleled research enterprise, and to promote coordination in its various lines...

REVISED LIST OF PROJECTS

During the year a revision was completed of the projects under way at all of the experiment stations, issued as a "Classified List of Projects of the Agricultural Experiment Stations, 1927." This list was prepared by Mr. George Haines with the assistance of the various specialists in the office, and with the generous cooperation of the experiment stations throughout the country. In preparing this list attempt was made to secure titles representative of the character of the projects at the present time, in order to make the list more intelligible and useful. This involved a good deal of correspondence, with frequent elaboration or expansion of project titles.

The new list includes over 6,600 projects, representing a small decrease in the number as compared with the preceding list for 1925-26. This decrease is the result of a revision of the project lists by stations, as urged by the office, in order to eliminate such as are not active at present and to concentrate investigation definitely on the more important and productive lines of research.

Of the total number of projects included in this list, 465 are Adams projects and 788 are Purnell projects, and 155 represent projects of the experiment stations in Alaska and the insular possessions. The projects are classified as follows: Agricultural chemistry 44, agricultural economics 491, agricultural engineering 268, animal husbandry 978, bacteriology and similar studies 12, botany 26, dairying 121, economic entomology 507, economic zoology 40, field crops 1,758, food technology 17, forestry 122, genetics 181, home economics 124, horticulture 1,197, meteorology 10, plant pathology 565, plant physiology 69, rural education 14, rural sociology 60, soils and fertilizers 538, and veterinary medicine 217.

It is worthy of note that nearly one-tenth of the projects are conducted in cooperation, a large share of them representing more or less formal cooperation with this department. This shows how closely the department and the experiment stations are working together in the study of problems of regional or national scope, or those of common interest. Proposed cooperative agreements are passed upon by the office, which maintains a file of such cooperative undertakings.

Conferences were held during the year on three of the national cooperative projects, namely, Factors Affecting the Quality and Palatability of

Meat, Marketing of Livestock and Livestock Products, and Rural Home Management Problems. At each of these conferences the office was represented and took part.

CONFERENCES, MEETINGS, AND COMMITTEE WORK

Conferences, meetings, and service on special committees as a means of promoting the work of the stations are demanding an increasing amount of time and attention. A number of the representatives of the office took an active part in such service during the year.

The chief of the office continued to serve as chairman of the Editorial Committee of the Journal of Agricultural Research, a task which requires considerable time for passing on manuscripts and assisting with the other members of the committee in maintaining the policy of the Journal as an agency for the publication of worthy contributions to research.

Representatives of the office took an active part in the work of the Association of Land-Grant Colleges and Universities relating to the progress and policy of the experiment stations. This work was represented particularly by two standing committees, the Joint Committee on Projects and Correlation of Research and the Committee on Experiment Station Organization and Policy, the chief of the office serving as secretary of both of these committees as in the past, with material assistance from members of the office force.

A report was prepared for the Joint Committee on Projects and Correlation of Research, 1927, which reviewed the progress of the committee's work in the 15 years of its existence, the enlargement of its activities following the passage of the Purnell Act, and the development of cooperation and coordination in research on a more extensive scale. The report of the Committee on Experiment Station Organization and Policy, 1927, emphasized the

continued need for critical scrutiny of outlines for new research projects to insure their being directed at specific objectives of limited range, rather than broad, general subjects, with procedure based on the actual status of inquiry in the particular lines chosen and employing methods and technique which have been found essential, or the rigorous testing of new means. The experience of the office in passing on projects proposed under the Federal funds indicates that such care and critical scrutiny are still needed, and that the preparation of project outlines often leaves much to be desired.

In a paper before the Association of Land-Grant Colleges and Universities, 1927, on Some Trends in Agricultural Research, by E. W. Allen, reference was made to finances and personnel, the essentials of investigators, the greater freedom for research, the measure of progress, the expansion of the idea of what is practical, and the clearer conception of research problems. The attempt was made to mark the progress which is being made, and to point to directions in which profitable administrative advances may be made. Other papers presented by members of the office staff were: The Place of Economic Research in the Solution of Present-Day Agricultural Problems, by Eric Englund, and The Status of Purnell Research in Home Economics, 1927-28, by Sybil L. Smith.

The Office of Experiment Stations also was represented at the celebration of the fiftieth anniversary of the North Carolina Agricultural Experiment Station, held at the State College of Agriculture on April 19, 1928. That State was the second in the country to make legislative provision for an experiment station, in 1877. At the anniversary exercises, an address was presented on The Rise of the Agricultural Experiment Station, which traced the development

of agricultural inquiry from its early beginnings, and brought out the important positions it has attained in all the States through the organization of experiment stations.

At the request of the Commissioner of Education of New York, the chief of the office participated in a survey of the State-supported institutions connected with Cornell University, made under the supervision of the State Department of Education. In this survey he was assigned the part relating to research in these institutions and, on the basis of the study made, prepared a report on the scope and organization of this research, the personnel, funds, and facilities, the correlation and coordination of results, and its general efficiency and effectiveness, with various suggestions.

The office was represented at the annual meeting of the World's Poultry Congress, at Ottawa, Ontario, in July, 1927; the American Society of Animal Production, at Chicago, in November, 1927; the American Home Economics Association, at Des Moines, Iowa, in June, 1928; and the Association of Southern Agricultural Workers, at Memphis, Tenn., in February, 1928.

INSULAR STATIONS

The Department of Agriculture maintains agricultural experiment stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands under appropriations made directly to it. The general administration of these stations has continued to be in charge of Dr. Walter H. Evans.

The lines of work pursued at the various stations have not been changed in any material degree during the year. Each station is working to develop a type of agriculture adapted to the region that will supplement industries that are already established. While many of the problems are distinctly local, their solution will be of value in other regions similarly situated.

There were only a few changes in the personnel of the stations during the year. Only one new position was created, that of cooperative demonstration agent for service on the islands of St. Thomas and St. John, in the Virgin Islands. The position was filled by the transfer of W. M. Perry, who had been horticulturist of the station on St. Croix for four years. He was succeeded at the St. Croix station by C. L. Horn, a graduate of the Oklahoma College of Agriculture. The work on St. Thomas and St. John is mainly an effort to interest the people of those islands in the production of fruit and vegetables for local consumption.

The retirement of Dr. C. C. Georgeson on December 31, 1927, marked an important event in the history of the Alaska stations. For nearly 30 years he planned and directed their work, often pioneering under trying circumstances, and to him must be given much credit for demonstrating the agricultural possibilities of Alaska and starting their development. G. W. Gasser, who was connected with the Alaska stations for more than 20 years, resigned December 31, 1927. Mr. Gasser was in charge of the Rampart station (now closed) from 1908 to 1921 and of the Fairbanks station from July 1, 1921, to the time of his resignation. His work with cereals, especially in the production by selection of what is now known as Siberian No. 1 wheat and his hybridization of barleys which resulted in Hybrid No. 19, were accomplishments of great value to the interior valleys of the Territory. He was succeeded at the Fairbanks station by F. L. Higgins, a graduate student of the University of Minnesota and for nearly four years assistant in agronomy at the experiment station connected with that institution. Mr. Higgins took up his new duties on April 11, 1928.

Attention has been called repeatedly to the fact that every one of the insular stations is undermanned, and there are many important problems, the solution of which would mean much to the communities, that can not be undertaken through a lack of men and equipment. All the support for operating the stations is derived from appropriations made by Congress. From 1920 to the close of the last fiscal year, the appropriations for all of the insular stations were increased by but \$22,640, much of which was required by acts which provided for salary adjustments. During the same period the increase in Federal contributions to agricultural experiment stations in the States amounted to \$60,000 for each State, and a further increase of \$10,000 each is provided for the current fiscal year. The different insular stations are sometimes criticized locally and impatience expressed that more rapid progress is not made on their problems, but with their limited resources it is impossible to expand the work to any considerable degree or to hasten results by employing additional workers.

The Alaska stations are in immediate need of buildings and equipment. A suitable residence and office building is needed at Fairbanks to replace the log structure built in 1908, on which constant repairs are necessary to keep it in habitable condition. Additional barns and granaries are needed at the Fairbanks and Matanuska stations to care for the rapidly increasing herds and for the cereal breeding experiments. New tractors and other equipment are needed. The present tractors have been in use for about nine years, doing field work as well as furnishing power for various farm activities, and should they break down at a critical time a whole season's work might be lost. A laboratory and a small greenhouse are greatly desired for the Matanuska station for plant breeding and propagating economic plants for distribution in the interior of Alaska. Due to differences in season, distribution from

the Sitka station is not satisfactory, and often shipments of plants fail to grow through their arrival at unseasonable times.

The Hawaii station needs additional personnel to carry on fundamental research in chemical problems and in plant diseases.

The Porto Rico station needs an entomologist and a chemist. Both of these positions have been vacant for a number of years, but the major equipment is on hand for research in these fields. There are numerous problems of insect pests and their control, soils, fertilizers, and their relation to crop production, the investigation of which is urgently important.

The Guam station is in need of a larger income so that it can be supplied with additional workers, buildings, equipment, and land. Attention is again called to the need of a trained agronomist to plan and carry on the work with crops. Since 1921 this has devolved on the animal husbandman, who is also director of the station, and it is expecting too much of one man to have the care of two distinct lines of work in addition to the directorship of the institution. The need for an extension agent is again suggested. This has been repeatedly recommended by governors of the island, the Guam Chamber of Commerce, and others. Club work with children is recognized as the best means of reaching the adult population of the island and bringing about improved agricultural practices. This was in successful operation until 1921, and more than half of the school children were enrolled in clubs of various kinds, but the work had to be terminated through a lack of funds. It should be renewed.

The principal necessity of the Virgin Islands station at this time is an animal husbandman, who should also be a veterinarian. The livestock industry is second in importance in the islands, but the station has no one to carry on experiments in breeding and feeding or in the care of livestock

or to see that they are protected from diseases. If such a man should be added to the staff he could attend to the pressing need of the industry and also act as quarantine officer to guard against the introduction of infectious diseases of stock. At present there is no one competent to perform this important function. Several governors of the Virgin Islands have strongly urged such an appointment and the undertaking of a campaign for the eradication of tuberculosis in cattle on account of the prevalence of that disease among the people.

The total incomes of the several stations for the fiscal year ended June 30, 1928, were: Alaska, \$76,240; Hawaii, \$54,940; Porto Rico, \$56,460; Guam, \$25,000; and Virgin Islands, \$25,000. The proceeds derived from the sale of products, which were deposited in the Treasury as miscellaneous receipts and were not available for station uses, as is the case in most States, were \$6,894.04.

PUBLICATIONS

The character and volume of the publications of the office did not materially change during the year. There were issued 38 documents aggregating 2,987 pages. These included the usual numbers and indexes of Experiment Station Record, reports on the work of the office and on the organization, administration, and progress of the work of the experiment stations, publications of the insular stations, and lists of station publications and of workers in agriculture in the land-grant institutions. A revised list of experiment station projects active in 1927 was also issued in mimeographed form.

The primary purpose of the publications of the office is to furnish comprehensive information regarding the organization, administration, and progress of agricultural research throughout the world, and to promote the more efficient organization and administration of such research in the experiment stations.

Experiment Station Record

Experiment Station Record continued to function efficiently as a clearing house of agricultural information and means of promoting agricultural research. Since its establishment in 1889, the Record has made available to investigators the essential facts in approximately 200,000 articles bearing on agricultural research. Within its present limits of 1,800 pages per year, it gives abstracts of about 10,000 carefully selected articles aggregating nearly 500,000 pages and recording in various languages the results of investigations in agriculture and home economics in all parts of the world. Special effort is made to obtain and abstract promptly, systematically, and completely the publications of the experiment stations and the Department of Agriculture. About one-third of the space available for abstracts in each issue of the Record is devoted to this purpose. This is a service not attempted by any other abstract journal, and serves not only to bring together the results of the work of these institutions in compact and convenient form for the use of investigators, teachers, extension specialists, and others, but also to disseminate the information widely throughout the world.

The fact that the literature of research in agriculture and home economics is rapidly increasing in volume and importance makes the problem of adequately reviewing it within the present space limits of the Record

increasingly difficult. There has been no substantial expansion of the Record since 1911, and the space now available is insufficient for an adequate review of the literature, with conditions constantly becoming more acute.

During the year special efforts were made to clear up the arrears of accumulated material and to issue the Record promptly. Volumes 57 and 58 were completed according to schedule, each consisting of nine numbers and index. These numbers contained a total of 7,168 abstracts, a slightly larger number than for several years. This material was supplemented by the customary monthly editorials, discussing the promotion of agricultural education and research and related questions, and brief notes in each issue on progress in this and foreign countries.

In order to cover more adequately the appreciable amount of literature available only in the Russian language, arrangements were made for the abstracting of some of the more important Russian periodicals by a member of the staff of the New Jersey Experiment Stations. A considerable number of abstracts were prepared and published under this arrangement.

Toward the close of the year an agreement was entered into with Biological Abstracts, under which carbon copies of all Record abstracts of the publications of the U. S. Department of Agriculture and the State agricultural experiment stations are made immediately available to that journal. This will give opportunity for their systematic inclusion in this world review of biological literature, of which, of course, agricultural research has come to constitute an important phase. Full credit to both the Record and the individual abstractors is to be given in such abstracts as are published. Provision is also contained in the agreement whereby similar copies of abstracts of certain publications not now available to the Record may be

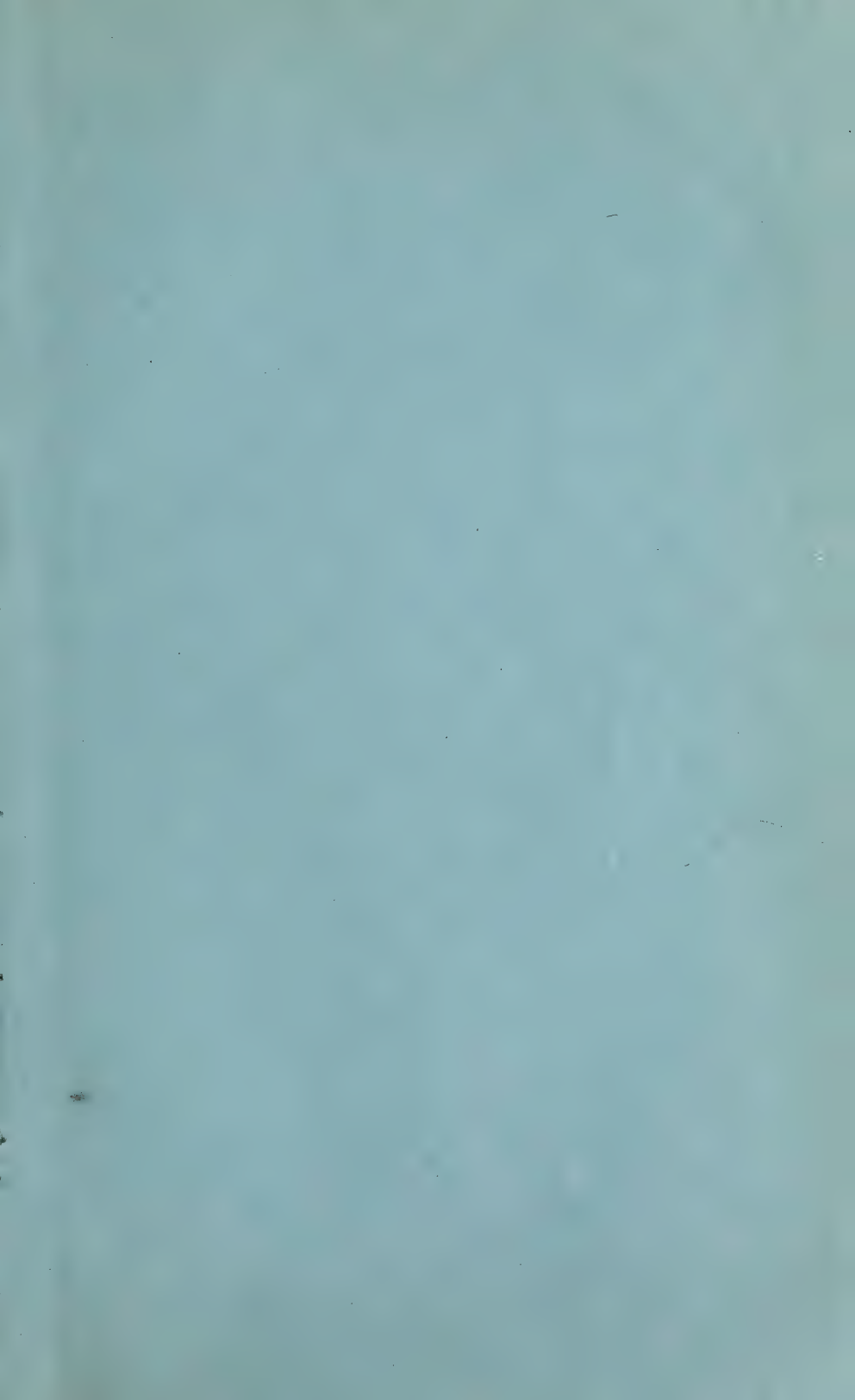
supplied by Biological Abstracts at a later date. This service, however, together with numerous other improvements for which a desire has frequently been expressed by librarians and others, will probably have to be deferred until additional space is available.

Reports on the Work of the Stations

A report on the progress of the experiment stations during 1926 was published and a similar report for 1927 was prepared for publication. These reports deal in some detail with administrative problems and relations of the office with the stations, give information regarding personnel, projects, additions to buildings and equipment, and State legislation affecting the stations, and include a classified list of station publications and detailed statements of income and expenditures and other data.

LIBRARY AND BIBLIOGRAPHICAL WORK

The library of the office maintained files of station and department publications and handled the increasing volume of literature assigned for review in Experiment Station Record. It also assisted in the preparation of certain special pieces of bibliographical work, including lists of references on canning and negro education and also a list of over 1,300 references to articles on station work appearing in publications not issued by the experiment stations. The third biennial supplement to Department Bulletin 1199, List of Bulletins of the Agricultural Experiment Stations for the Calendar Years 1925 and 1926, prepared by the library, was published in December, 1927.



DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE DIRECTOR OF THE EXTENSION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE,
EXTENSION SERVICE,

Washington, D. C., September 1, 1928.

SIR: I have the honor to present herewith the report of the Extension Service for the fiscal year ended June 30, 1928.

Respectfully,

C W. WARBURTON, *Director.*

Hon. W. M. JARDINE,
Secretary of Agriculture.

PERSONNEL

The personnel of the Extension Service in Washington on June 30, 1928, consisted of 177 persons, of whom 5 were employed in the office of the director, 125 in the office of cooperative extension work, 27 in the office of exhibits, and 20 in the office of motion pictures. The field force on the same date consisted of 4,120 persons, of whom 4,105 were cooperatively employed by the department and the States in extension activities. The 15 field workers not cooperatively employed included 2 persons employed by the office of demonstrations on reclamation projects, 4 full-time employees of the office of cooperative extension work, and 9 employees of the office of exhibits. In addition to the persons employed cooperatively by the department and the States, nearly 1,050 were engaged in extension work in the States who are not under appointment from the department.

FUNDS ADMINISTERED

The direct Federal appropriation for the Extension Service during the fiscal year was \$1,792,225, of which \$1,424,000 was for farmers' cooperative demonstration work, \$11,540 for general administrative expenses, \$125,000 for special extension work looking toward corn-borer control, \$25,000 for the employment of extension agents in flooded areas, \$108,045 for exhibits, \$38,640 for demonstrations on reclamation

projects, and \$60,000 for farm-forestry extension. In addition, Federal appropriations amounting to \$5,880,000 were allotted to the States for extension work under the terms of the Smith-Lever and supplementary acts. The States, counties, and other agencies contributed \$13,468,100 for cooperative extension work. The total of all of these items, the sum available for extension work in the United States during the fiscal year, was \$21,140,325.

COOPERATIVE EXTENSION WORK

PERSONNEL

The office of cooperative extension work continued under the direction of C. B. Smith, chief, and J. A. Evans, assistant chief. The consolidation of the office of agricultural instruction, formerly a detached unit, with the office of cooperative extension work added seven employees to the office staff, a number which was partly offset by resignations and furloughs. On June 30, 1928, the Washington staff of the office comprised 10 administrative and supervisory officers, 13 organization field agents, 14 subject-matter field agents, and a clerical force of 88.

During the greater part of the year R. G. Foster, field agent in club organization for the Eastern States, was on furlough for advanced study at Cornell University. In cooperation with the Bureau of Agricultural Eco-

nomics, B. B. Derrick was employed as extension specialist in cooperative marketing, effective July 1, 1927. Miss Florence L. Hall was appointed on May 16, 1928, as extension home economist in the Eastern States. O. B. Martin, who was in charge of extension work in the Southern States, became director of extension work in Texas February 1, 1928. Since that date J. A. Evans, assistant chief, has been in charge of the work in the South, in addition to his other duties. G. H. Collingwood, extension forester, resigned June 25, 1928, to accept a position with the American Forestry Association.

The entire State field staff on June 30, 1928, numbered 5,161 persons, an increase of 106 during the year. Of this number, 3,675 were permanently located in the counties, of whom 2,318 were in county agent work, 941 in home demonstration work, 145 in boys' and girls' club work, and 271 in negro extension work. The county extension agents were supplemented in their work by 804 full-time and 200 part-time subject-matter specialists located at the State agricultural colleges. There were 417 supervisors and assistant supervisors and 65 administrative officers and immediate assistants. During the year there was an increase in the field staff of 72 county workers, 7 administrative and supervisory workers, and 27 subject-matter specialists. Of the total number of field workers, 4,105 were cooperative employees of the department, practically all engaged either in county extension work, supervision of county work, farm-management demonstrations, farm-forestry extension, or emergency corn-borer control work.

FUNDS

The total funds available for cooperative extension work from all sources during the fiscal year were approximately \$20,952,560, an increase of about \$890,000 over the previous year. Of the total funds, 35.7 per cent, or \$7,484,460, was contributed by the Federal Government, exclusive of the use of penalty envelopes; and 29.6 per cent, or \$6,217,058, was from State appropriations to the agricultural colleges and other State agencies. The remaining 34.7 per cent, or \$7,251,042, came from county appropriations for extension work and from contributions by local organizations and individuals. About 94 per cent of all funds used for co-

operative extension work in 1928 came from public sources.

Of the Federal funds, \$5,880,000 was made available by the Smith-Lever Act and an appropriation supplementary thereto and \$1,604,460 from direct appropriations to the department. Of the total funds, \$12,967,465 (61.9 per cent) was allotted for extension agents in the counties; \$1,116,260 (5.3 per cent) was allotted to the State agricultural colleges for administration; \$2,318,040 (11.1 per cent) for supervision of county extension workers; and \$4,142,605 (19.7 per cent) for the employment of subject-matter specialists. The remaining 2 per cent, or \$408,190, was for activities of the Federal Extension Service at Washington.

Several bills were passed and approved during the fiscal year which have a great bearing on the future of cooperative extension work. The Capper-Ketcham Act, which provides additional funds for the further development and expansion of extension work, was approved on May 22, 1928, and went into effect on July 1. This act authorized an appropriation of \$980,000 annually, of which \$20,000 goes to each State and to the Territory of Hawaii. The act also authorizes an additional \$500,000 to become available for use during the fiscal year beginning July 1, 1929, and annually thereafter.

The Territory of Hawaii was accorded the benefits to be derived under the Smith-Lever Act by an act which was approved on May 16, 1928. Under this legislation Hawaii will receive, beginning July 1, 1928, funds sufficient to enable it to carry out the provisions of the Smith-Lever Act.

County extension agents for the flood-devastated area of the Mississippi Valley were assured by the act of January 26, 1928. This act authorized an appropriation for the employment of agents in counties lacking sufficient funds to continue the support of extension activities. The agricultural appropriation act of May 16, 1928, provided \$400,000 for this purpose, of which \$110,000 was made available for immediate use during the remainder of the year.

PROGRESS

RESULTS

Extension agents reported more than 4,500,000 instances in which improved practices were adopted by farmers, farm women, and 4-H Club members

during 1927.¹ This was an increase of more than 400,000 over the previous year. Increased popularity was recorded in such practices as soils, cereals, legumes, forage crops, potatoes, horticultural crops, forestry, dairying, animal husbandry, poultry, rural engineering, agricultural economics, foods, nutrition, home management, house furnishings, and home health and sanitation, whereas decreases were noted in practices involving cotton, rodent and insect control, and clothing. These results furnish reliable evidence of the greater popularity of cooperative extension work among farmers and their families during the year.

In all, 772,185 practical result demonstrations were carried on by farmers and farm women as object lessons to their neighbors. This number was a substantial increase over the 644,784 demonstrations that were carried on in 1926. Boys' and girls' 4-H club members completed 776,029 demonstrations, as compared with 673,997 in 1926. These demonstrations were largely responsible for influencing farming people to adopt recommended practices, although the use of meetings, tours, the press, bulletins, campaigns, and other mediums helped greatly in bringing the results of such demonstrations to the attention of a great many persons.

Assisting in the improvement of farm and home practices were 243,247 volunteer local leaders, who acted as demonstrators and otherwise aided the extension agents in the promotion of extension work. Of these local leaders, 183,065 worked with adults and 60,182 with boys and girls in 4-H clubs. Extension agents held 38,064 leader-training meetings to teach local leaders the fundamentals of extension leadership. The approximate attendance at these meetings was 352,000.

ADULT ACTIVITIES

Agricultural agents and specialists spent a larger part of their time with farm crops in 1927 than on any other project. Poultry, animal husbandry, dairy husbandry, and horticulture were the other leading lines of agricultural activity to which agents devoted their time. In 35,321 communi-

ties agricultural extension programs were worked out with the farming people which provided plans for more efficient farm production and marketing and for better living conditions. In acquainting people of the counties with information pertinent to farm practices and marketing county agricultural agents held 351,829 field meetings and prepared 253,800 news items for local newspapers and the farm press. This extension effort on the part of county agricultural agents and volunteer local leaders influenced farmers to better their agricultural practices in 3,031,587 instances.

Of activities relating to the farm home, clothing received the greatest attention of agents and specialists, although the percentage of time devoted to clothing activities was less than last year. Community activities, foods, and nutrition, in the order given, were the projects which received the next largest amount of extension agents' time. Home demonstration agents were assisted in their local work with farm women by 44,000 voluntary local leaders, who contributed much to the success of the work. In more than 18,800 communities farm women cooperated with home demonstration agents in formulating extension programs of work for the following year. More than 16,000 community clubs, with a total membership of 307,565 farm women, were reported by home demonstration agents. During the year home demonstration agents made 258,038 visits to 146,660 different farm homes and prepared for newspapers 68,946 news articles. As a result of these and similar activities rural women were influenced to adopt better home practices in 1,449,627 instances.

BOYS' AND GIRLS' 4-H CLUB ACTIVITIES

The total enrollment in 4-H club projects during 1927 was 619,712 farm boys and girls, of whom 64.4 per cent completed all work incident to the projects in which they were enrolled. This was an increase in both respects over 1926, when 586,156 were enrolled and 62.8 per cent completed their work. Club members conducted 776,029 result demonstrations in the production of farm crops and livestock and in home improvement, or slightly more than did the adult farmers and home makers. Like their parents and neighbors, these young farm boys and girls met together in groups to discuss their problems and present solutions

¹All extension field reports are for the calendar year; hence figures contained in this report on cooperative extension work except where the fiscal year is indicated are for the year ended Dec. 31, 1927.

and to plan ways in which they could be of greater service to their communities. There were 44,188 such groups, known as 4-H clubs, in 1927, or about 3,000 more than the previous year. These local clubs were trained by co-operative extension agents assisted by 60,182 local leaders who voluntarily gave their time and effort to the work. As a means of widening the sphere of extension influence, 15,583 teams of club members were trained to give public demonstrations of the better methods which they learned in 4-H club work.

Among the measurable productive results which club members achieved during the year were the cultivation of about 80,000 acres of field, truck, and orchard crops, of which 40,952 acres were in corn, 13,068 acres in cotton, and 4,211 acres in potatoes; the management of 136,500 head of high-quality livestock, including 68,116 hogs, 26,079 dairy animals, and 18,278 sheep; and the handling of 1,465,353 standard-bred fowls. They canned 2,617,718 jars of fruits, jellies, and vegetables and made 473,258 articles of clothing.

The second national 4-H club camp was held in Washington, D. C., June 21 to 26, inclusive. The camp was attended by two farm boys and two farm girls from each of 39 States, who were accompanied by two State leaders or assistant leaders from each of the States. The program included conferences of State supervisors and of club members on club problems, inspirational and educational talks, visits to Government departments and to points of interest in and about Washington, and recreation.

EMERGENCY ACTIVITIES

The mobility of the staff of the co-operative extension service in giving immediate and efficient aid in serious agricultural emergencies was again demonstrated during the year. In the South the flood in the Mississippi Valley had left in its wake a widespread area of devastated farms. The emergency thus created made it necessary for the extension workers to utilize all available resources for the purpose of rebuilding and rehabilitating these farms. Regular extension programs were temporarily laid aside, and the energy of the entire extension staffs in this area, especially in the States of Arkansas, Louisiana, and Mississippi, was devoted to emergency work.

Because of the lack of funds available from taxation many counties were unable to continue the work of county agricultural agents, home demonstration agents, and negro agents. Congress immediately recognized the seriousness of the situation and passed an act authorizing the appropriation of funds for the continued employment of extension agents already employed and the employment of new agents where necessary to aid in building up the farms in the flood-devastated area and in restoring them to their former productivity. The act appropriating funds for the Department of Agriculture for the fiscal year 1928-29, approved May 16, 1928, provided \$400,000 for the employment of these emergency agents, of which \$110,000 was made available for immediate use during the remainder of the fiscal year. As soon as these funds were authorized, appointments of county extension agents for the flooded area were made as rapidly as possible.

Extension workers continued their efforts to place the devastated farms on a self-supporting basis. Improved varieties of garden, cotton, and soybean seed were distributed widely by the American Red Cross with the assistance of cooperative extension agents. The results which were obtained during the year indicate that a serious emergency has been helpfully met by the cooperative extension service and that the work carried on will prove to be of great permanent benefit in the areas involved.

Similar service was rendered by extension agents in Vermont following the devastating flood which visited that State late in October, 1927. Emergency funds were made available to Vermont to aid the counties in maintaining their extension staffs.

The European corn borer continued its threatening advance toward the Corn Belt States, although the progress of the borer was materially retarded through the compliance of farmers with the control regulations issued in New York, Pennsylvania, Ohio, Indiana, and Michigan during the campaign in the spring of 1927. A survey of the infested area showed that there were one and a half times as many borers in 1927 after the completion of the campaign as in 1926 when no concerted effort was made to control the borer. This compared favorably with the increase in 1926 when fully four times as many borers were in existence as in 1925. This retardation in the spread of the borer is at-

tributed to the control measures employed in the spring campaign and the willingness of farmers to cooperate.

It was recognized by extension workers that although the borer is a serious menace to the corn growers of the country, if farm practices were changed to meet the new conditions the outlook need not be alarming. On this basis, State and county extension workers redoubled their efforts during the fall of 1927 and the spring of 1928 in giving public demonstrations in effective mechanical control methods, such as plowing, raking, burning, and low cutting of standing cornstalks, in giving illustrated talks at community meetings, in conducting tours by farmers to heavily infested areas, in the distribution of bulletins, circulars, lantern slides, and posters on control methods, and in the release to weekly and daily newspapers of news items, photographs, and mats and stereotypes of illustrations giving the latest authentic information on the progress made in checking the advance of the borer and methods of control. This educational work, which had begun as an emergency measure, was gradually absorbed during the year in the regular program of extension activities of the cooperative extension service of the department and the State agricultural colleges.

In the Western States the breaking of the St. Francis Dam in California in March, 1928, released a flood of water which covered more than 10,000 acres of farming land in Ventura County. At the request of the governor, 21 men of the staff of the California extension service were assigned to make a survey of the agricultural damage done. County agents from all sections of California were called upon to assist in the survey. Farmers in the flooded area were sympathetic toward this emergency work and appreciated the service given by extension workers.

EXTENSION STUDIES

This unit, with M. C. Wilson in charge, continued to gather data on the effectiveness of various phases of cooperative extension work as carried on by county extension agents. A new line of work—the study of the cost of utilizing various existing methods for increasing the spread of recommended farm practices—was also undertaken during the year. The collection, summarization, and digest of State and county extension reports, the compilation and study of data on

farmers' institute work in this country, and of general extension activities in foreign countries were continued.

FIELD STUDIES

Four additional States cooperated during the year in studying extension work, making a total of 17 States in which extension studies of various kinds have been made. In Ohio information was obtained on the receipt and use of bulletins and on the effectiveness of poultry extension. In Kansas, Rhode Island, and Michigan the studies related to the general effectiveness of the extension program in influencing rural people to adopt new practices. Information was also obtained regarding the part the various means and agencies commonly employed in extension teaching have played in bringing about the adoption of practices. Plans were completed for a second study of extension work in Illinois during July, 1928.

Altogether 1,977 farm and home records were obtained during the year, making a grand total of 13,561 individual farms and homes from which records have been obtained regarding contact with extension workers and the use of extension information. Fifty-four members of the State extension services were trained in the collection of field data during the year, making a total of 253 who have participated in the collection of data for extension studies, exclusive of the members of the staff of the office.

Data obtained in the later extension studies have tended to corroborate the conclusions drawn from the earlier studies. In Kansas information was obtained for the first time regarding the influence of the age of farmers upon the adoption of improved agricultural practices. Contrary to the opinion held by many extension workers, fully as high a proportion of farmers between 36 and 55 years of age made use of extension information as of the farmers 35 years of age and less. Eighty-five per cent of the farmers who were 35 years old and under adopted recommended practices, 90 per cent of those between 36 and 45, 89 per cent of those between 46 and 55, and 81 per cent of those 56 years old and over. Desire to learn is apparently more important than age alone. The same situation exists in the relationship of age of farm women and the adoption of improved home practices in the same area.

A comparison between the information obtained on bulletin distribution

and use in Ohio, Wisconsin, and Minnesota in 1927, and in four sections of the country in 1912, shows that of the 3,698 farmers from whom records were obtained in 1912, 43.3 per cent received bulletins. Of those receiving bulletins, 48.2 per cent made use of the information. Of the 1,676 farmers included in the survey in 1927, 1,035, or 61.8 per cent, received bulletins, of whom 640, or 61.8 per cent, put into practice the information thus obtained.

The percentage of farmers obtaining bulletins has increased materially since the establishment of the nationwide system of cooperative extension work. A higher proportion of the farmers receiving bulletins are making use of bulletin information, which would also seem logical because of the many other extension means and agencies which are now supplementing bulletin information and building confidence in the research work of the State experiment stations and the United States Department of Agriculture.

Reports were published or prepared during the year covering studies in Kansas, Minnesota, New Jersey, Ohio, Pennsylvania, and Wisconsin. Reports of studies made in Pennsylvania and Minnesota were issued as printed circulars of the State extension services. All other reports were mimeographed by the Federal office. A manuscript for a department technical bulletin has been prepared from a study of the accumulated information made available to date. This proposed bulletin brings out the relative value of the various means and agencies employed in extension teaching, traces the influence of subject matter upon choice and effectiveness of methods, and makes comparisons between the time devoted to the various methods and the results ascribed to these methods.

A study of the cost of using various extension methods was begun during the year. Through the courtesy of the New Jersey State College of Agriculture, arrangements were made for H. J. Baker, extension director, to devote five months to this problem. Plans for the study of extension costs were discussed with several national leaders in cost-account research before the collection of data was undertaken. Mr. Baker visited 18 of the 48 States and arranged for them to contribute data. These data are being summarized, and it is expected that a report of the findings will be available by fall.

During the year the results of field studies were presented at the annual meeting of agricultural college editors at Fort Collins, Colo., and at the annual conferences of extension workers in Arizona, California, Massachusetts, Michigan, Minnesota, Montana, North Carolina, North Dakota, Utah, Washington, and Wyoming. Of the 48 States, 32 have cooperated in these field studies, either in conducting an extension study or in having the data from extension studies presented at annual conferences.

SUMMARY AND DIGEST OF REPORTS

Approximately 3,500 county extension agents reported the results of all phases of extension work. Reports were also received from subject-matter specialists and from State supervisors. These reports were tabulated, indexed, and analyzed. A statistical summary of the results was mimeographed and issued as Extension Service Circular 76.

Digests of the narrative reports received from State and county extension agents and subject-matter specialists were prepared for field distribution. They covered the subjects of seed-potato improvement and certification, marketing activities of farm women and girls, sweet clover, orchard spraying, and local leadership in clothing extension work.

FARMERS' INSTITUTES

One more State discontinued farmers' institute work during the year, leaving 11 in which institutes were conducted. In all 2,260 institutes were conducted, which extended over a period of 3,425 days and consisted of 8,018 sessions with a total attendance of 1,163,245 persons. In Wisconsin the State appropriation for farmers' institutes was increased 50 per cent. Information regarding farmers' institutes and extension work carried on in foreign countries was collected and compiled by J. M. Stedman. Three reports were issued summarizing the publications received relating to extension work in England, Wales, Sweden, Poland, Belgium, Italy, Czechoslovakia, Germany, Canada, Mexico, Peru, Colombia, Union of South Africa, Ireland, Australia, and Scotland.

VISUAL INSTRUCTION AND PUBLICATIONS

The use of visual instruction, publications, press material, periodicals, photographs, lantern slides, charts,

posters, and radio to disseminate information on extension activities was continued under the direction of Reuben Brigham. Extension motion pictures and exhibits previously handled in this unit were transferred during the year to the division of subject-matter field agents. There was a general increase in the use of visual aids among extension workers during the year. The popularity of lantern slides, especially those on motion-picture film, increased.

PUBLICATIONS

The following new publications written by members of the staff of the office of cooperative extension work were printed and released during the year:

Circular 17, A Ten-Year Review of Home-Management Extension, 1914-1924, by Madge J. Reese; Circular 22, Ten Years of Agronomy Extension, 1915-1924, by O. S. Fisher; Circular 30, Farm-Management Extension, 1914-1924, by H. M. Dixon; Miscellaneous Publication 8, A Review of Five Years of Fact Organization and State and Regional Program Making in the Western States, and a Report of the 1927 Extension Conference, by W. A. Lloyd; Report on Cooperative Extension Work, 1925; Extension Service Handbook in Agriculture and Home Economics; and a card featuring boys' and girls' 4-H club work.

The following publications were reprinted to supply the demand for copies from extension workers:

Miscellaneous Circular 85, Boys' and Girls' 4-H Club Work Under the Smith-Lever Act, 1914-1924, by G. E. Farrell; and Department Circular 385, How to Prepare and Display Extension Exhibits, by H. W. Gilbertson.

The following contributions were made by the staff to the series of mimeographed extension service circulars:

48, After five years—Review of fact organization and State and regional program making in the Western States, by W. A. Lloyd; 49, Local leadership—Clothing project: Excerpts from 1925 annual reports of State and county extension agents, by M. J. Reese and M. C. Wilson; 50, Home demonstration work, 1926, by Grace E. Frysinger; 51, Measuring the progress of extension work—A study of 590 farms and farm homes in two Illinois counties, by M. C. Wilson, W. H. Smith, and Kathryn Van Aken; 52, Does education pay the farmer? by F. A. Merrill; 53, Use of illustrative material in the promotion of boys' and girls' 4-H club work, by C. H. Hanson; 54, Seed-potato improvement and certification—Excerpts from 1926 annual reports of county extension agents, by F. C. Meier and M. C. Wilson; No. 55, Special courses for preparation of agricultural and home-economics extension teachers, by E. H. Shinn and F. A. Merrill; 56, Marketing activities—Farm women and girls—Excerpts from 1926 annual reports of State and county extension agents, by M. C. Wilson; 57, Influence of bulletins,

news stories, and circular letters upon farm practices with special reference to methods of bulletin distribution, by M. C. Wilson; 58, Teaming with the county agent, by H. W. Hochbaum; 59, A study of land-grant college curricula with reference to special courses for the preparation of agricultural and home-economics extension teachers without considering agricultural, home-economic, and closely related science subjects, by E. H. Shinn and F. A. Merrill; 60, Looking forward in home demonstration work, by Grace E. Frysinger; 61, Orchard spraying—Excerpts from 1926 annual reports of county extension agents, by F. C. Meier and M. C. Wilson; 62, Foreign agricultural extension activities—England, Wales, Sweden, Finland, Poland, and Spain, by J. M. Stedman; 63, Sweet clover—Excerpts from 1926 annual reports of State and county extension agents, by M. C. Wilson and O. S. Fisher; 64, Effectiveness of dairy extension—A study of 192 dairy farms in Mercer, Hunterdon, and Warren Counties, N. J., 1926, by M. C. Wilson and A. M. Hulbert; 65, The agricultural extension program in relation to farm income and farm life, by C. B. Smith; 66, County agent standards, by H. W. Gilbertson; 67, Foreign agricultural extension activities—Ecuador, Brazil, Czechoslovakia, Germany, and India, by J. M. Stedman; 68, Agricultural instruction—A means of establishing better racial relations in southern communities, by E. H. Shinn; 69, Opportunities for students of agricultural colleges, by E. H. Shinn; 70, Lantern slides for rural communities, by C. H. Hanson; 71, The place of the 4-H clubs in the American system of public education, by Alfred Charles True; 72, Extension work with rural young people above 4-H club age, by R. A. Turner; 73, Farmers' institutes, 1927, by J. M. Stedman; 74, Summary of distinctive features of 1927 home demonstration reports of the 11 Western States, by Madge J. Reese; 75, Foreign agricultural extension activities—England, France, Sweden, Belgium, Italy, Switzerland, and Germany, by J. M. Stedman; 76, Statistical results of cooperative extension work, 1927, by M. C. Wilson; 77, Extension results as influenced by various factors—A study of 532 farms and farm homes in Clay and Sedgwick Counties, Kans., 1927, by M. C. Wilson and A. L. Clapp; 78, Distribution of bulletins and their use by farmers, by M. C. Wilson; 79, Effectiveness of poultry extension—A study of 612 farms with poultry in Franklin, Miami, and Guernsey Counties, Ohio, 1927, by M. C. Wilson and J. E. McClintock; 80, Objectives in a program of rural-life improvement, by E. H. Shinn; 81, Report of European trip, by Grace E. Frysinger; 82, Challenge of the unified extension program, by Eugene Merritt.

The visual-instruction and editorial division also prepared for publication a series of seven posters showing the need for retarding the spread of the European corn borer and explaining the principal methods found to be practical in the control of this pest.

During the year circular letters on six different subjects were prepared by the division in cooperation with the southern division, and stencils were sent to the States requesting help in the preparation of their local letters. Various counties in Alabama, Arkansas, Florida, Mississippi, South Caro-

lina, and Virginia were helped in this manner. The most popular letter was on the storage of eggs in the spring for home use later when prices of fresh eggs are higher. Stencils for this letter were sent to eight extension agents, who mimeographed the letters on their own letterheads and mailed them to local farmers and farm women.

INFORMATION SERVICE

Emphasis in extension news during the year was placed on the issuance of the monthly mimeographed periodical, the Boys' and Girls' 4-H Club Leader. Material was collected and prepared for twelve 15-page issues. Each of these issues contained approximately 65 items relating to 4-H club achievements and methods of work in the different States and presented one or more developments in the club work of from 25 to 35 States.

News items relating to various phases of extension activities presented on a national and regional basis were prepared and disseminated to daily and weekly papers and farm journals and magazines through the channels of the department press service. These releases numbered 134. There were also sent upon request to farm papers, special writers, and informational news organs 1,416 photographs of extension activities, accompanied by information descriptive of the subjects illustrated.

The unit continued to handle the corn-borer information service in cooperation with State extension divisions and State departments of agriculture. One of the principal and popular activities of this service was the preparation and release to cooperating and other interested persons of a mimeographed house organ entitled "With the Corn Borer." This was issued as occasion demanded during the fall and early winter, but between February 1 and July 1, when intensive educational work for the clean-up was in progress, it appeared weekly. During the year 34 numbers were released, varying in length from 4 to 8 pages. To obtain a further dissemination of facts relating to corn-borer control 13 special press releases were prepared. The special cut and mat service to weekly and daily papers in the campaign area continued in popularity and effectiveness. Other activities included the wide distribution of a 14-page mimeographed publication entitled "Questions and Answers on the European Corn Borer," and the furnishing of special information and photographs

to the press, magazines, writers, teachers, extension agents, and others.

VISUAL INSTRUCTION

At the request of State extension divisions talks on photography and the preparation and use of charts, posters, lantern slides, and other visual material, followed by practical demonstrations and discussions, were given at conferences of extension workers in Maryland, Massachusetts, Minnesota, Missouri, Montana, Nebraska, New Jersey, Rhode Island, and Virginia.

PHOTOGRAPHIC SERVICE

In cooperation with 13 State extension divisions, several carefully planned series of field photographs illustrating extension activities were obtained for use in publications, news, lantern slides, exhibits, and the like. The States visited were Alabama, Arkansas, Illinois, Maryland, Michigan, Mississippi, New Jersey, New York, North Carolina, Pennsylvania, Ohio, South Carolina, and Virginia. Photographs were also taken in the District of Columbia and in Canada, the latter picturing damage of corn by the corn borer and methods in use for control. The total number of photographs taken on these trips was 1,975.

A wide variety of photographs on farm and home subjects is kept in the photographic reference library of this unit. This library was consulted frequently by department employees and field workers and cooperators. New photographs to the number of 2,733 were added to the library during the year, which now includes 33,963 photographs.

Approximately 47,250 negatives, prints, slides, enlargements, charts, posters, and drawings were requested and prepared for the use of extension workers. Of these the office of information completed 3,912 negatives, 30,934 prints, 10,213 slides, 366 enlargements, and 478 miscellaneous items, including blue prints. The remaining orders, amounting to 48 enlargements, 1,165 slides, and 147 prints, were filled by the commercial concerns holding the department's contract for this work.

The art work of the unit consisted of the preparation of wash drawings for the series of 7 educational corn-borer posters; the coloring of 5,056 lantern slides, 72 enlargements, and 13 photographic prints; the preparation of 1,137 drawings and special designs, 60 posters, 93 charts and graphs; and

the lettering of 1,137 cards, placards, and signs.

LANTERN SLIDES

There were 1,104 sets of glass lantern slides and 122 slide series on film lent to State extension divisions, teachers, and cooperating agencies during the year. The loan collection of lantern slides was augmented by the addition of 28 new series, making a total of 189 series available for loan. Of these, 159 were on cooperative extension work and 30 were prepared especially for the use of teachers. The following 22 series were prepared during the year for use in extension work:

Series 167, Transferring bees to modern hives; 173, Marketing feeds through dairy cows; 177, Tobacco diseases and their control; 180, How insects attack garden vegetables and methods of control; 181, Cabbage diseases; 223, How to grow potatoes; 224, Bulk handling of grain on the Pacific coast contrasted with sack handling; 225, Farm sheep raising; 226, Seed corn; 227, Cultivating the corn crop; 228, Cooperative feeder cattle and lamb pools; 230, National 4-H club camp; 231, The European corn borer; 232, Control of the European corn borer; 233, 4-H club songs; 234, Chicken lice, mites, and other external parasites; 235, Cooperative marketing of California walnuts; 236, Cattle grubs or heel flies; 239, Care of the laying flock; 242, Seeing Washington; 243, Famous club members; 245, Barberry eradication, a practical means of reducing black stem rust losses.

The following six series were prepared for use in schools:

Series 60, Control of household pests destructive to property; 61, Control of household pests detrimental to health; 62, Equipment used in teaching clothing in negro schools; 63, Equipment used in teaching food in negro schools; 64, Equipment used in teaching housekeeping and home making in negro schools; and 65, Eggs considered from the consumer's standpoint.

Lantern-slide series placed on film strips during the year included the following 20 subjects:

26, Sweet-potato culture; 150, How to get rid of rats; 158, Quack grass; 159, Plant propagation; 178, Better cotton on fewer acres; 179, Lime and limestone; 181, Cabbage diseases; 188, Range management on the national forests; 190, Food makes a difference; 196, Clover production; 214, Cooperative marketing of burley tobacco; 216, Forest planting in the Northeastern States; 224, Bulk handling of grain; 228, Cooperative feeder cattle and lamb pools; 230, National 4-H club camp; 231, European corn borer and its work; 232, Control of the European corn borer; 233, Boys' and girls' 4-H club songs; 235, Cooperative marketing of California walnuts; and 236, Cattle grubs or heel flies.

Cooperative extension agents, schools, and organizations purchased from the commercial concern holding the contract 968 copies of positive prints, made from department film-slide negatives. The unit also assisted

seven States in the preparation of 14 film-slide negatives from their own photographs for local use.

RADIO

A national hook-up of 21 broadcasting stations was arranged in cooperation with the department press service and the National Broadcasting Co. and associated stations to permit 600,000 boys' and girls' 4-H club members throughout the United States to participate in a national club meeting which was held at the second national club camp at Washington, D. C., on the night of June 23. This feature proved to be very popular, and several hundred club members in many States sent telegrams and letters reporting a clear reception of the program. A telegram was received from Minnesota estimating that 30,000 club members participated in the program.

Although no regular extension features were prepared for radio release during the year, special material on the control of the corn borer was prepared and released by the radio service to the corn-growing States during a period of nine weeks in March and April.

AGRICULTURAL INSTRUCTION

The consolidation of the office of agricultural instruction with the office of cooperative extension work became effective June 1, 1927. The purpose of this consolidation was to coordinate more closely the work in agricultural instruction with the program of cooperative extension work, and to provide opportunity for collecting data and making studies of problems, methods, and activities in extension education. This alignment has resulted in directing the work more toward studies of problems and activities relating directly to agricultural and home-economics extension work and less to investigations of methods of teaching agriculture in secondary and elementary schools. Notwithstanding these changes, the section continued to supply teachers with lantern slides of the department, classified lists of department publications, prints, charts, and various other kinds of material most of which was in available form for immediate use.

The aim was to maintain a service to both teachers and extension workers in agriculture and home economics and to extend to them the facilities of the department by supplying lists of the sources of illustrative material and helpful information. In order to make

the service of greatest value close co-operation was maintained with subject-matter specialists of the department, with other extension workers, and with leaders in the various States who were interested in the development of improved methods and practices in agricultural and home-economics extension education.

GROWTH OF WORK

Considerable time was devoted during the year to the preparation of illustrative material in the form of slides and charts for the use of extension workers and teachers. There was an increase in the demand for lantern slides from teachers of agriculture and home economics in a large number of the States. There was also an increased demand for illustrative material on all forms of educational work relating to agriculture and home economics. Cooperation was carried on with subject-matter bureaus of the department in the preparation of six series of lantern slides for the use of extension workers and teachers in home economics.

During the year 21 educational charts were prepared and printed, making a total of 53 charts available for distribution. These illustrated charts cover such subjects as breeds of livestock, important steps in the production and distribution of such crops as cotton, corn, and wheat; grades of beef; milk and butter production; cheese making; dried-fruit industry; potato cultivation, spraying, and harvesting; sugar cane; sugar beet; tobacco; rice; fiber plants, cotton manufacturing, and wool production and grades of wool. There were 31 new charts in preparation at the end of the year. The completed charts have been widely distributed to teachers of agriculture and home economics and to extension workers. So great was the demand for these charts that the free supply became practically exhausted. Arrangements were made whereby additional charts may be purchased from the Superintendent of Documents, Government Printing Office, at a price of 1 cent for each chart.

THE YEAR'S STUDIES

Two studies relating to special courses for the professional training of agricultural and home-economics extension workers were completed during the year and issued as department extension service circulars. One of these studies dealt with the status of train-

ing courses offered at land-grant institutions for those contemplating or already doing extension work. This investigation also called for the opinions of administrators as to what the training should comprise. The other study consisted of data as to the opinions of county extension workers regarding the kind of training that should be offered. The latter data were regarded as having special value inasmuch as they came from those workers who have dealt directly with local problems in county extension work and should know considerable about the kind of training that is most needed for successful extension teaching.

The manuscripts giving lessons on potatoes and lessons on corn for the use of teachers of agriculture in rural schools were revised and prepared for printing. A study on the opportunities before students of agricultural colleges was made during the year and issued as an extension-service circular. A manuscript was prepared by a member of the staff in cooperation with the Bureau of Entomology entitled "Cotton or Boll Weevil." It was written in simple language designed especially for members of boys' 4-H clubs who have cotton projects and others interested in the study of cotton. The bulletin should be of considerable value to anyone interested in the study of cotton production under boll-weevil conditions. A study of leadership training for adults who do agricultural or home economics extension work was practically completed. The study is based on data received from extension workers in almost every State. An investigation was made during the year with reference to the value of agricultural instruction in improving racial relations in the Southern States and the data were published as one of the extension service circulars. A study of the educational value of 4-H club work was undertaken, but as the material for this study must be assembled from all States the larger part of this study will be carried over to the coming fiscal year.

Considerable work was done by a member of the staff for the committee on instruction in agriculture, home economics, and mechanic arts of the Association of Land-Grant Colleges and Universities. During the year a study of methods of measuring college-teaching results was begun. A preliminary report on the study was made at the annual meeting of the association in

November, 1927. At the request of the committee this study was continued during 1928. The necessary data are being obtained through the cooperation of 20 of the land-grant institutions in different sections, 12 of which were visited. Conferences were held with the presidents of the institutions, deans of education, deans of agriculture, and professors of chemistry. A member of the staff, acting as secretary of the committee, collected the data on which the study is based and prepared the report for the consideration of the committee at its annual meeting.

Members of the staff attended, served on programs, and participated in discussions at regional conferences of agricultural teachers, the American Home Economics Association, and the American Country Life Association. At the annual meeting of the Michigan Rural Life Association a paper was read on the major objectives in a program of rural-life development. At the annual meeting of the Association of Land-Grant Colleges and Universities a paper was read on opportunities before students of agricultural colleges. At the national conference on negro education and at a State association for colored teachers a paper was read on agricultural instruction as a means of establishing better racial relations in southern communities.

SUBJECT-MATTER FIELD AGENTS

The direction of the activities of subject-matter field agents continued under A. B. Graham. During the year G. H. Collingwood, the extension forester, resigned, and B. B. Derrick was appointed as field agent in cooperative marketing. Close cooperation of subject-matter field agents was maintained with the various bureaus, and research data collected during the year were organized and presented to State extension workers for field use. Methods of disseminating the information and of increasing its influence were carefully studied. The general plan covering the year's work was to reach more people by making the approach to them through a variety of means and agencies, by studying their habits and reactions, by analyzing their annoyances and satisfactions, by stimulating them through the want-solution-action-satisfaction formula, by the use of simple practices, and by making such practices easy of accomplishment.

One of the outstanding features characterizing the work of subject-

matter specialists at the agricultural colleges was the increasing tendency to cooperate with each other in the formulation of an extension farm and home program and in a more complete understanding of the interrelations of the subject-matter extension features necessary to the carrying out of a farm adjustment and better practice program. Subject-matter specialists were more inclined than previously to study local economic conditions, demands from local farmers, and available material and data covering all phases of the problems under consideration.

County extension agents were aided in their work by 804 full-time and 200 part-time extension specialists employed by the States as follows: Agricultural engineering, 46; agronomy, 97; animal husbandry, 93; child care and training, 5; clothing and millinery, 58; dairying, 85; entomology including apiculture, 39; farm management, 47; foods and nutrition, 58; forestry, 36; health and sanitation, 6; home management, 36; horticulture and pomology, 86; rodent control, 4; rural organization and marketing, 67; plant pathology, 27; poultry, 85; visual instruction, 11; publicity, 67; extension schools, 20; and unclassified, 31.

AGRONOMY

The improvement and standardization of crops grown primarily for direct marketing and the production of feed crops sufficient for local livestock consumption were the main objectives of crop-extension activities in 1927.

The improvement and standardization of field crops grown primarily for direct marketing were brought about principally through seed improvement by means of crop standardization and adaptation. During the year such work was a major activity in 37 States and in the other 11 States some work was done. Improvement was usually brought about through a farmers' seed-improvement association cooperating with the extension service and the experiment station. Such improvement was obtained through demonstrating the value of improved seeds, production by association members of seed of approved varieties for sale to their neighbors and other farmers in the State, and the inspection and certification of these varieties for a seed supply of high quality.

Reports of county agricultural agents indicate that 100,306 farmers used for the first time improved seeds for cereal crops in 1927, and that

62,162 farmers used improved seed for soy beans, cowpeas, and other varieties of legumes. There were 21,939 who used improved cottonseed, and 34,486 who used improved alfalfa seed for the first time.

The main extension effort to bring about the growing of sufficient feed crops for local livestock consumption was directed toward legume production. Three legumes—alfalfa, sweet clover, and soy beans—constituted by far the most important crops grown for this purpose in 1927 as result of extension influence.

Soil-improvement work in 1927 centered on (1) legume production, (2) green manuring, and (3) the economic use of fertilizers.

In legume production the main problem was one of supplying lime. This was especially pronounced in the eastern half of the United States. Limestone deposits continued to be the principal source of agricultural lime, but marl deposits were increasingly used, particularly in northern Indiana, Kentucky, Michigan, Minnesota, and Wisconsin, where marl was dredged from swamps and lake beds. In Missouri and eastern Kansas extension agronomists cooperated with the lime-quarry companies, the lumber companies, and elevators in arranging to have local supplies of lime available for the farmers. In Illinois an incomplete report indicates the use of between 750,000 and 800,000 tons of lime in 1927.

The large increase in the use of lime made it possible to grow more legumes for green manuring. Sweet clover was the most important of such crops used in the Central and Western Plains States. In the Eastern and Southern States rye, velvet beans, cowpeas, and similar crops were used to a large extent.

During 1927 more attention was given to the problem of the proper use of commercial fertilizers than in preceding years. There continued to be much interest in home mixing of fertilizers, but the most outstanding increase came from the activities of the extension agronomists in the use of high-analysis fertilizers. Ohio and Missouri were among the first States to take up this work, and they still lead. In Missouri, in 1927, only 1.4 per cent of all sales were of medium and low grade quality. During the year 22 States promoted the use of high-analysis fertilizers.

Weed control furnished another difficult problem in soil improvement. The wheat-producing States of Kansas,

Minnesota, Montana, North Dakota, and South Dakota gave much attention to this problem because of high dockage in the marketing of grain.

In 1927, 48,754 demonstrations in soil improvement were carried out by farmers in cooperation with extension agents. In all 279,774 farmers were reported as adopting improved practices in soil improvement during the year. Advice in the use of commercial fertilizers was followed on 139,793 farms, in the use of lime on 47,677 farms, and in the better care of farm manure on 47,982 farms.

HORTICULTURE

Pruning, fertilizing, cultivating, thinning, cover cropping, propagation, grading, packing, standardization of varieties, and marketing were horticultural extension phases given attention by extension workers in 1927. These activities were necessarily supplemented by measures undertaken for the control of diseases and injurious insects.

The standardization of varieties of tree fruits grown commercially was an outstanding activity. In New England it was realized that too many unprofitable and ordinary varieties of apples were being grown. Agreement was reached by extension horticulturists in these States upon the following seven varieties: McIntosh, Northern Spy, Delicious, Rhode Island Greening, Baldwin, Wealthy, and Gravenstein. As a result hundreds of trees of other varieties are being grafted over to these seven varieties, known as the New England Big Seven, and new orchards of these varieties are being planted.

In California cost accounting was carried on in connection with a number of pear orchards with valuable results. The cost of such operations as pruning, cultivating, and spraying in some orchards was several times as much as in other orchards. The figures were of especial value in showing some owners that their orchard operations were too expensive.

There were 13,206 result demonstrations with tree fruits conducted by farmers in 1927. The number of 4-H club members engaged in this field was very limited, only 658 demonstrations being conducted by them. Plantings of improved varieties of tree fruits were made on 11,566 farms, and improved pruning methods were adopted on 18,636. There were 61,071 farms reported on which some im-

proved practice in the improved production of tree fruits was adopted.

The planting of improved stock, better pruning methods, and proper fertilization and cultural methods were the more important phases of bush and small-fruit production advocated by extension workers. There were 1,756 result demonstrations reported conducted by farmers in 1927 and 490 by members of the 4-H clubs. The planting of improved stock was reported by 4,364 farmers, and pruning methods were adopted by 2,349. There were 11,302 farms reported on which improved practices in the production of bush and small fruits were adopted.

Grapes received about as much attention from extension agents as bush and small fruits. The planting of improved stock and improved pruning, fertilization, and cultivation for higher yields and better quality were recommended. There were 1,704 result demonstrations in grape production reported as having been conducted by growers in 1927. Farms on which improved pruning practices were adopted numbered 4,439, and on 1,931 farms improved stock was planted. There were 9,323 farms reported on which some improved practice in grape production was reported.

In market gardening the principal lines of extension effort related to the production and use of certified seed, improved seed strains, plant structures for growing seedling plants, disease and insect control, fertilizing, cover crops, culture, standardized grades and packs, and improved marketing methods. There were 6,159 result demonstrations in market gardening reported conducted by adult growers in 1927. Four-H club members also displayed considerable activity in this field, as 2,099 demonstrations were conducted by them. There were 9,841 farms on which improved seed was used. The total number of farms reported on which some improved practices in market gardening was reported was 27,077.

The improvement and beautification of the farmstead and particularly the immediate surroundings of the farmhouse had a wide appeal. There were 26,281 demonstrations conducted in some phase of landscape gardening by adults in 1927, 22,029 being reported by county home demonstration agents. Similarly, of 29,824 demonstrations conducted by juniors, 27,979 were reported by home-demonstration agents. Rural women and girls, therefore, were unquestionably much more active than the men and boys in putting

landscape improvements into effect. There were 88,839 farms reported on which improved practice in landscape gardening was adopted.

FORESTRY

Extension effort during the year centered on increased forest planting to provide a continuous crop of timber products, to solve the problem of waste on idle land, to stop erosion, and, to some extent, to control damage. The preservation of fence posts and other farm timber resulted from some of the extension activities. Measuring farm timber and teaching the principles of marketing the products of the farm woods were carried on in a few States.

There was a tendency on the part of woodland owners, particularly in the South, to save their woods rather than to clear them. In the Northeastern States the use of waste lands for forests claimed attention. In Louisiana remarkable progress was made toward cooperation with the State foresters in protection against fire. The planting of windbreaks was continued in the prairie States.

Although forestry accomplishments during the year were not particularly outstanding, they were nevertheless apparent. The greatest influence of the extension service was toward the planting of forests on waste land owned by farmers. County extension agents reported that 6,082 forest or wood-lot plantings were made on an area of 19,455 acres, that 4,509 farmers were assisted in the management of 222,135 acres of farm woods or about twice the area involved in 1926, and that 1,924 farmers planted windbreaks.

One of the most outstanding achievements was the extent to which forestry was made interesting to boys and girls through the 4-H clubs. During 1927, 3,163 boys and girls were enrolled in forestry projects, and 2,192 carried their projects to completion. To an increasing extent boys and girls have taken up woods management. As a result of forestry extension with adults and juniors 15,807 instances were reported in which better practices were accepted.

PLANT PATHOLOGY

Plant-disease control has become an essential feature of the successful farm program. Reductions in yield, complete crop failures, blemishing of the plant parts grown for the market, de-

terioration in storage or transit, all are brought about by the action of plant diseases. As crops have been grown intensively in particular sections, the plant-disease control problem has become more and more serious.

The control of plant diseases affecting more than 30 important crops was brought about by extension agents in 1927 through (1) improved cultural and handling methods; (2) eradication of diseased plants, diseased plant parts, and alternate hosts carrying a disease; (3) use of disease-resistant varieties; (4) planting of disease-free seed; (5) proper crop rotation; and (6) treatment of seed. Plant-disease surveys were invaluable in aiding extension pathologists to advise county extension agents as to the presence of field-crop disease in any given locality, the extent to which the crops were affected by the disease, and the method or methods of control that could be profitably applied by the farmer.

Market studies were also useful. Inspection reports showing the amount of smut present in wheat at the market and records of smutty wheat received at local elevators, with information on discounts given on such grain, had much to do in bringing about campaigns on wheat-smut control.

The copper-carbonate treatment of seed wheat to prevent smut was the most widely adopted practice. First introduced by extension agents in 1924, this treatment has gained steadily in popularity. This is indicated by the increase from 8,324 farmers in 39 States who treated seed wheat for smut in 1924 to 50,175 farmers who so treated their seed wheat in 1927.

As a result of seed-potato treatment demonstrations extension workers showed growers in some localities a method of increasing yields as well as quality. In the Kaw Valley of Kansas demonstrations during the last seven years showed increases in yields ranging for the period from 19 to 53 bushels per acre. As a result of these demonstrations 80 per cent of the acreage was planted with treated seed in 1927, as compared with 13 per cent in 1921. A total of 33,289 farmers planted improved or certified potato seed during the year.

RODENT CONTROL

Elimination of crop injury due to prairie dogs, ground squirrels, pocket gophers, jack and cottontail rabbits, field mice, house mice and rats, porcupines, and moles was a measure included in the rodent-control program

for 1927. The greatest amount of effort was expended during the year in the control of prairie dogs and ground squirrels, and approximately 15,000,000 acres were treated with 1,312 tons of grain and 550,000 pounds of fumigants. This work was in a large measure carried on in the far Western States and in adjoining border States, such as Kansas, Nebraska, Oklahoma, South Dakota, and Texas. In the East a limited amount of work was done with rats, woodchucks, field mice, and rabbits. A number of county-wide rat campaigns were conducted, with satisfactory results.

A considerable advance in methods of controlling injurious rodents was made, especially in the control of porcupines. A system of poison stations and baiting was worked out that provides a practicable means of preventing some of the very serious depredations of these rodents in forests. Considerable progress was made with the use of a poison formula containing thallium sulphate in poisoning some of the species of prairie dogs and ground squirrels which were ordinarily averse to taking poison baits effective in controlling other species.

Encouraging progress was made in rat control by stimulating the wider use of powdered red squill, which does not unduly endanger other animal life. County agents particularly were interested in this method of control, inasmuch as most of them have refused to recommend any method that would endanger other animal life and incur the possibility of serious criticism.

Demonstrations in effective rodent control were conducted by 8,801 farmers, and 110,057 farms were reported on which control practices were adopted.

ENTOMOLOGY AND BEE CULTURE

The control of insects was an important feature of extension activities during the year. Entomologists and county extension agents assisted farmers in the control of such insects as the European corn borer in the States bordering on the Corn Belt, the Hessian fly in the wheat-growing States, the codling moth, and other insects in the eastern fruit areas, the boll weevil in the South, grasshoppers in the West, and the potato beetle and truck-crop insects in various regions.

Extension forces in New York, Pennsylvania, Ohio, Michigan, and Indiana put on an intensive educational campaign in 84 counties infested with the

European corn borer. Demonstrations were held in clean plowing, tours of farmers were organized to visit heavily infested fields in Canada, Ohio, and Michigan, and the newspapers and farm journals cooperated in giving the fullest possible publicity to methods of control.

One of the outstanding features of extension work in entomology during the year was the wheat-growers' school held in Dodge City, Kans. A well-rounded program for wheat production, including entomological activities, was prepared in the extension division. County agents were acquainted with the plans of the school and nominated the community leaders who should attend from each of their counties. These community leaders attended the school at least two days and then assisted the county agents in putting across the projects in their several communities.

In all, 13,407 result demonstrations in insect control were conducted by farmers in 1927, and on 149,264 farms the adoption of some improved practice was reported.

Demonstration apiaries showing how to care for and manage bees for high-quality honey production were a feature of the work with beekeepers. The use of improved hives, swarm control, and disease prevention were among the phases emphasized. In Washington State extension effort was directed toward increasing the production per colony through reducing disease, improving the type of hive, avoiding winter loss, and procuring better stock. A State cooperative marketing association was organized during the year and an intensive campaign to promote honey consumption was put on through the public school, the press, and fairs.

Beekeeping in New York State was built around 32 permanent demonstration apiaries located in 20 counties. These were used as object lessons and points of contact for the extension entomologists. The average yield during the past season in these demonstration apiaries was 75 pounds as compared to 36 pounds for colonies not in the demonstrations.

Extension agents in all States reported that 1,762 adult and 617 junior demonstrations were conducted during the year and that 5,491 farmers adopted the recommended practices.

ANIMAL HUSBANDRY

The fiscal year 1927 found the livestock industry in general on a profitable basis, which enabled extension

workers and farmers to give more thought to common problems without being distracted by the necessity for meeting emergency situations. Consequently, more progress was made in the improvement of breeding stock, use of economical feeding methods, control of diseases and insect pests, and the supplying of high-grade products to meet market requirements. Extension workers manifested a decided disposition to view their work through the eyes of the farmer as it affects his entire farm enterprise and not from the standpoint of one subject-matter line, which has been too often true in the past.

Western producers of both cattle and lambs for Corn Belt feed lots for finishing catered to the demands of customers in adjusting production practices so as to supply the types, ages, quality, and numbers of their product preferred by the trade. The pronounced preference of the consumers for meat of lightweight cuts of extreme tenderness resulted in the slaughter of younger animals. This preference caused premium prices to be paid for the favorite product. Baby-beef and lamb club work, conducted as extension projects, served as demonstrations in pointing the way in which farmers might take advantage of the new situation. A striking tendency throughout the sheep-producing areas of the West was to market the product as lamb instead of mutton, as was the former custom.

The popularity of lean pork products, such as ham and bacon, and the decreasing need for large quantities of lard brought new problems in swine production. All of these factors tending toward a shorter life of market animals brought about a situation that required a larger number of breeding stock in order that the same tonnage of meats might be supplied to the consuming public.

More effort was devoted to the efficient use of livestock feeds; the raising of larger percentages of the young; their protection from diseases, parasites, and unfavorable elements; and to feeding them, in accordance with the best scientific knowledge, from feeds largely home grown. Selection of the proper types of breeding animals to conform to breeding requirements and which produce offspring suitable for modern consumption standards made much progress during the year. The use of protein supplements to balance rations, especially in swine production, has rapidly improved feed-

ing methods. Measures for control or eradication of infectious diseases were also widely adopted. The application of the principles of the McLean County system of swine sanitation has become practically general throughout the commercial hog-producing areas of the entire country.

DAIRYING

Better sires, dairy-herd improvement or testing clubs, feeding schools, and dairy-calf clubs were the principal dairy-extension activities in 1927. The better-sires work made marked progress in several States. In Pennsylvania it centered in the cooperative bull associations, of which there were 63. Only 3 associations disbanded during the year, and 19 new associations were organized. In Louisiana the growth in numbers of active associations was from 9 on January 1, 1927, to 21 on January 1, 1928.

The Southern States, with their low percentages of purebred dairy sires in service and correspondingly low production of milk per cow, were mainly concerned with the placing of purebred sires and the elimination of scrub sires. In Mississippi this culminated in a series of county-wide scrub-bull-eradication campaigns. In the campaigns already conducted in Mississippi, 223 purebred sires were reported as placed, and 1,677 scrub sires were shipped out.

Local leaders were enlisted in carrying out the dairy-herd-improvement program. By this method associations were organized in many counties, practically eliminating the personal canvass for association members and resulting at the same time in stronger organizations.

Work was carried on to a limited degree with the factory patrons in producing a better quality of milk and cream and with the factories in improving methods of manufacture and in grading milk and cream with a price differential to stimulate the production of the higher grade.

More than 22,500 adult and 23,000 junior demonstrations were carried on during the year. Extension agents assisted 14,452 farmers to obtain purebred sires and 21,325 to obtain high-grade or purebred females. In all, there were more than 429,000 instances of the improvement of dairy practices through extension work.

POULTRY

The poultry industry continued to grow during the year not only on the

general farms but in the commercial areas, due principally to the wider use of mechanical equipment. Farms that maintain from 1,000 to 25,000 laying hens and broiler plants that raise 50,000 broilers during a season increased in number. Poultry colonies were developed on tracts of land set aside for the purpose by real-estate brokers in many sections. This class of farmers, though still comparatively small, presented entirely new problems to the extension poultryman.

Since 70 to 90 per cent of the poultry income comes from the sale of eggs, the main problem of the farmer is to obtain economic egg production. Extension workers helped in the solution of this problem in 1927 by assisting farmers to adopt improved practices in feeding, breeding, housing, sanitation, and marketing. The elimination of the low-producing hen was emphasized. In former years this was attempted through culling demonstrations conducted by the county extension agents and specialists. The more recent tendency has been to eliminate the personal-service feature and to develop trained leaders and associations to carry on the activity. Intensive training schools of from two to five days' duration were held in many of the States in 1927 for the training of local professional cullers. Many hatching associations required their official cullers to pass the requirements of these schools. The fact that the number of birds handled by these representatives in certain States runs into the hundreds of thousands shows that this system has been very far-reaching.

Since feeding constitutes about 66 per cent of the expense of keeping a flock, major attention was paid to the proper feeding of the birds. The feeding project was also linked up very definitely with the culling work, because most agents and specialists now insist that a flock be fed properly for from four to six weeks before culling.

In improving poultry housing, cooperation with lumber dealers was effective. Bulletins and blue prints were distributed, exhibits of small models were made, and house-raising demonstrations were held, a full-sized house being constructed in one or two days' time in selected localities. "Grow healthy chick" campaigns were a feature of poultry extension work in several States. These campaigns usually started with a survey of brooding and rearing conditions in the State. In one State the survey of the previous year showed a loss of over 30

per cent of the chicks hatched, whereas data obtained from cooperators who followed the rules of the campaign showed an average loss as low as 8 per cent.

On 92,409 farms in 1927, growers were induced by extension agents to improve feeding methods. The control of lice and mites was undertaken on 54,671 farms. Flocks were culled on 79,777 farms. Demonstrations in poultry production were conducted by adult growers on 50,102 farms. Of the members of the 4-H clubs, 56,756 conducted demonstrations, 56 per cent of whom were girls. One of the aims of poultry extension work in 1927 was to get the club work more nearly on a farm-flock basis. The reported average for 1927 was 26 birds per member. There were 259,222 instances in which farms were reported as having adopted improved practices in poultry production.

RURAL ENGINEERING

The control of soil erosion and the building of soil-saving dams were major rural engineering activities in 1927. Terraces and soil-saving dams were constructed on 41,199 farms during the year and prevented erosion on 1,140,588 acres, at an estimated cost of \$5 to \$10 per acre. The terracing in one year of an area approximately as large as Delaware would seem to indicate rapid progress, but when these figures are compared with the hundreds of millions of acres in need of such improvement the necessity of a more general effort along this line is apparent. The construction of terrace systems has not only prevented the formation of washes and gullies but has resulted generally in an immediate increase in cash returns from the land.

On 53,255 farms more than 257,000 acres of cultivated land were cleared of stumps and stones. No attempt was made to increase the area cultivated by clearing new land. Much of the work was done with pyrotol, the surplus war explosive, of which more than 13,591,000 pounds were distributed.

Owing to the wet growing season of 1927, the installation of irrigation improvements was materially reduced, and drainage work increased. Irrigation systems were installed by 1,640 farmers and drainage systems by 5,380 farmers.

Extension activities to improve poorly arranged farm homes without modern heating, lighting, water, and sewage

systems contributed greatly to the saving of time and energy of the farm women and to the comfort of the farm home. Extension agents reported that 3,067 new dwellings were constructed and 4,897 old dwellings were remodeled according to plans furnished by extension engineering specialists; that 4,088 sewage disposal plants, 3,487 water systems, 568 heating systems, and 2,816 lighting systems were installed according to recommendations.

The improving of housing conditions for animals, crops, and equipment received considerable attention from extension specialists. They reported that 33,977 farm buildings other than dwellings were constructed or remodeled according to plans furnished by them.

In an effort to overcome the high cost of power and labor in growing and handling farm crops, farmers were reported buying considerable modern farm machinery and equipment with which they had little or no experience. Numerous meetings were therefore held to demonstrate the proper use of such equipment, including plows, planters, cultivators, harvesters, tractors, gas engines, silage cutters, and seed cleaners. Altogether, 151,478 farms reported the adoption of improved agricultural engineering practices as a result of extension efforts.

FARM MANAGEMENT

The cooperative extension service aided the farmers in their farm-management adjustments through supplying information relating to (1) the immediate management program, (2) the long-time outlook for farming in the locality, (3) how to study the business as a whole from the standpoint of efficient farm management, and (4) how to determine the things that count most in increasing income. This information was based on (1) the factors external to the farm that determine in a broad way the choice of enterprises in different areas, (2) the selection of enterprises and the relative amount of each making for an economic organization of the individual farm, (3) ways and means of obtaining low cost of production or operation, and (4) short-time adjustments that will be made to meet fluctuations in prices.

Extension workers gave to farmers the results of research and demonstrations, showing them the bearing of such results on economic farm organization and operation practices. They

assisted farmers to keep adequate records of the farm business as a basis for measuring the efficiency of their farms in relation to that of other farmers working under similar conditions. Farm records were kept by 30 to 50 farmers per county in a large number of counties in 1927. These records, in addition to furnishing guidance to the individual farmers keeping them, were helpful in determining the recommendation of county extension agents as to desirable farming systems in their counties.

Extension agents encourage farmers to keep and analyze cost of production records in order to determine the relative profitableness of different farm enterprises, how such enterprises could be combined to give a larger volume in return, and how to effect economical operation. They aided farmers in determining their production and marketing plans by supplying information on available supplies of farm products, price trends, and on the intentions of farmers in planting and breeding operations.

In extension program building, available facts on what has happened in agricultural production, prices or costs, movements, and consumption have been collected, assembled, and studied. This information affecting farm organization or operation along broad lines, coupled with the facts from individual farms, formed the economic contribution in extension program building. The analysis and interpretation of this material and the application of it to the farmers' problems involved a close working relationship of all subject-matter specialists contributing to the advancement of an agricultural extension program in a region or county. After the economic facts supplied by the farm-management specialists were properly related with facts procured by other specialists, meetings were held where the facts were used by the farmers in organizing the local extension program. Such meetings were State, regional, or county in scope.

In 1927, 26 States conducted organized farm-management extension programs with one or more men devoting full time to the project. There were five other States where some work was done by part-time activities of one specialist. County agents in 1,448 counties reported farm-management extension activities. County agents in 835 counties assisted 12,487 farmers in summarizing and analyzing their accounts. Of these farmers, 9,185 made changes in their business as a result of keeping accounts. In 793 counties, 17,241

farmers were assisted in keeping cost-of-production records. The number of meetings and schools that were conducted by extension specialists was 3,980, with a total attendance of 163,870. County agents in 740 counties assisted 25,275 farmers in adopting crop, livestock, or complete farming systems. In 1,448 counties, county agents assisted 70,522 farmers in adopting improved practices relative to farm management.

Meetings dealing with timely economic information and the agricultural outlook were held in 24 States. In 18 States a monthly publication of timely economic information was issued by the subject-matter department or by the extension service, or jointly by both. In most States the farm-management extension specialist aided in the publication or dissemination of this periodical. Work designed primarily for fact analysis as a basis of improving extension programs was carried on in 15 States. In five States regional or county economic conferences were conducted in which the farm-management extension specialists participated.

MARKETING

The year's improvement of farm-marketing practices was largely in (1) the standardization of farm products, (2) the development of quality products salable at the highest net profit, and (3) improvement in the organization and conduct of agencies for co-operative marketing.

The problems in cooperative marketing that confronted the farmers were (1) lack of understanding of the underlying principles of marketing and their application to cooperative marketing, (2) unwillingness to go all the way with their organization to insure successful cooperation, and (3) difficulty in obtaining the cooperation of producers, individual marketing agencies, bankers, and others who have not been convinced of the desirability of cooperative marketing as an economic practice. Lack of authoritative information as to possibilities and limitations of cooperative marketing, management, sales policies, price analyses, business practices, and sound organization has likewise hampered farmers in their efforts to market co-operatively.

The shipping-point inspection of fruit and vegetable crops and the establishment of United States grades for eggs, butter, grains, and other crops, and the improvement in prices

received by producers meeting such inspection and grades greatly reinforced extension teaching as to the desirability of standardizing farm products.

Cooperative marketing schools or conferences lasting from two to four days, conducted by the extension services of several States, were a new feature during the year. Most of these schools were held jointly by the State extension service, the Federal Division of Cooperative Marketing, and leading cooperative organizations. They provided instruction in cooperative marketing for extension workers and for employees and directors of cooperative associations. The courses were prepared so as to emphasize the problems, successes, and failures of associations within the State and to give the leaders in the movement a more comprehensive and intimate knowledge of conditions. Attendance at the schools averaged approximately 150 people.

Extension workers aided farmers further by supplying general market information through the press or by radio. Publications were issued giving the results of research work on certain products and the application of such results to marketing practices. In some sections, both farmers and farm women were aided in the direct marketing of their products on curb market, with appreciable success.

Extension workers aided in the organization of 1,021 cooperative-marketing associations in 1927, with a membership of 70,710. The total sales of the new associations amounted to \$10,546,106. Cooperation was continued with 2,413 associations previously organized, the total sales of which were \$193,241,104 and the profits to members \$7,650,865. There were 421,973 farms reported on which improved marketing practices were adopted.

FOODS

Extension activities in foods related particularly to food selection, production, preparation, and preservation and in 1927 were accorded the same popularity that has distinguished them for several years.

In meeting the dietary needs of the farm family much emphasis was placed on producing at home an adequate supply of food. In the South county home demonstration agents continued to give major attention to gardens, home poultry flocks, and home dairies as sources of food supplies. They rec-

ognized the fact that to improve the diet and health of the farm family there must be an adequate supply of the right foods. It was also recognized that the bulk of the foods needed could be grown on the farm itself and that their addition to the diet need not add to the cash outlay for the family's food. Agents were given full cooperation by farm women in this effort to develop and maintain a sufficient home-grown food supply.

In a number of States nutrition specialists, horticultural specialists, and county extension agents cooperated in giving special attention to "food budget" gardens. These gardens were planned to furnish a succession of vegetables and fruits during the growing season with a balance for canning and storing.

County home demonstration agents reported 76,610 food-production demonstrations conducted by women. Of this number, 41,497 were with gardens, 26,202 with home poultry flocks, and 8,911 with the home dairy. The number of demonstrations on food production conducted by members of 4-H clubs reported by county home demonstration agents was 63,373. Of these, 39,763 were with gardens, 20,296 with poultry, and 3,314 in dairying. County home demonstration agents reported the adoption of improved practices in food production on 212,517 farms. Of these practices adopted, 109,111 were in relation to gardens, 72,326 in relation to poultry, and 31,080 in relation to dairying.

Proper food preparation, no less than food selection and food production, was recognized by extension agents as an important factor in bringing about the adoption of a wholesome and satisfying diet by the farm family. It was recognized that the production and selection of foods needed in the diet must be followed by their proper preparation so that they will be palatable and attractive to both children and adults. In consequence, extension agents made instruction in food preparation an important feature of work in 1927. Vegetable cookery, in particular, was emphasized.

Rural women conducted 58,206 result demonstrations in food preparation during the year, and 4-H club members conducted 81,903 such demonstrations. Improved practices in bread making were reported as having been adopted by 50,294 women, in meat cookery by 52,732, in vegetable cookery by 93,000, and in dairy dishes by 51,791. There were 264,105 homes re-

ported in which improved practices in food preparation had been adopted.

Food preservation, curing, and storage were emphasized as activities supplemental to home food production and the maintenance of an adequate family diet. The canning of fruit, vegetables, and meats, the preservation of eggs, and the storage of the less perishable fruits and vegetables were widely practiced. The home income was considerably increased in many States through putting up canned goods, jams, jellies, and preserves for select private trade or specialized trade with hotels, dining-car departments of railroads, and the like.

Like the garden budget, the food-preservation budget was used to advantage in planning the amount of fruits and vegetables required to keep the family supplied with needed amounts of these products when they could not be obtained fresh from the garden and orchard.

There were 40,513 result demonstrations relating to food preservation conducted by rural women and 60,399 by members of the 4-H clubs in 1927. The number of women reported as adopting improved practices in preserving fruits and vegetables was 81,502, and 31,281 were reported as adopting practices in preserving meats and fish. In 18,329 homes better provision was made for storing food. The amount of food products reported canned was 15,755,085 quarts. There were 11,860,490 pounds of meat cured and 842,287 pounds of fruits and vegetables dried. In all, 133,412 homes were reported as adopting improved practices in food preservation.

NUTRITION

Nutrition was a vital part of the extension program in all States in 1927. The principal results obtained were (1) greater interest in an adequate diet as a controlling factor in good health, (2) a clearer understanding of what good health really means, (3) a better knowledge of the points of good growth in children, (4) more carefully planned meals, and (5) improved food habits in children and adults.

Nutrition extension effort was directed toward creating a desire on the part of individuals for physical fitness and giving them an understanding of what constitutes such a condition. Standards of condition and build for children were emphasized in particular, with the result that many parents expressed keen interest in pre-

natal and preschool feeding and in child training. Home makers and members of the 4-H clubs were taught to check their daily diet against a food-selection score card. The score cards emphasized the use of milk, fruits, vegetables, whole cereals, adequate protein, and water. Food values of common foods were explained and applied to meal planning. Adaptations of diet standards to the needs of the young child, of school children, of the aged, and of those suffering from constipation, underweight, overweight, and anemia were explained.

In many States home demonstration agents and local women's groups cooperated with the schools in directing and supervising health education through "keep-growing" programs or "better-food" clubs, thus extending and reinforcing the home-feeding program. The food-selection score card was used here also. The growth-work program of the 4-H clubs, with its checking of food and health habits and correction of defects, was instrumental in opening up similar work for the rest of the school population. Agents emphasized the well-packed lunch from home, the supervised lunch period, and the hot dish at noon.

With the slogan, "Make yourself your own best exhibit," the club girls in many States checked food and health habits and worked for improvement on the basis of a growth and health standard. Some States also extended this work to club boys. In cooperation with State boards of health, most States held health contests based on thorough physical examinations. Many held preliminary county contests also. Widespread correction of defects and improved food and health habits among club girls and boys resulted and helped carry out the new club slogan, "Watch us grow." State health champions were entered in the health contest at the national 4-H club congress in Chicago, the objective of this contest being to hold up a standard of physical fitness and encourage club members to work toward it in their local clubs. In the far West the State health champions went to Camp Plummer in Portland, where a similar contest was held.

Extension workers were the first to offer the rural home maker a simple guide to an adequate daily diet in the food-selection score card. They were also the first to vitalize health teaching by providing a standard of good growth and good functioning. By

using local children in demonstrating this standard, extension workers met with marked success in helping parents to observe children more intelligently and to keep a stricter watch on their day-by-day development.

There were 43,931 result demonstrations relating to nutrition conducted by rural women and 54,451 by members of the 4-H clubs in 1927. The balancing of family meals according to approved methods by 64,304 women and the preparation of better school lunches by 37,616 women, due to extension influence, were reported. The number of homes carrying out improved practices in child feeding was 32,825. Some improved practice in nutrition was adopted in 168,293 homes.

CLOTHING

Interest in clothing work continued in 1927. That rural women appreciated the assistance given in the selection of their clothing with regard to attractiveness, suitability, and economy, whether such clothing was constructed at home or purchased ready-made, was evident from the reports of extension agents. In many communities women requested clothing instruction for the second, third, and even the fourth consecutive year.

Clothing-construction contests and style shows emphasizing designs, colors, and materials suitable for different types of women were conducted in a number of States. These and other similar influences continued to lessen differences between the dress of country and town women and break down the distinction between the two in their appearance and manners. As a further result more thought was expended by rural women on clothing problems of the home. The consideration of suitable clothing for children of school and preschool age and its relation to the welfare of the growing child was one of the newer phases receiving attention in 1927.

Other newer projects related to selection of shoes and hosiery and the purchase of household supplies, such as bed and table linens, yard goods for clothing, and draperies. Sewing-machine clinics increased in number. Maryland and Montana reported 1-day clothing clinics, and Missouri reported a clinic on millinery. Texas reported an intelligent-shopping project. Three States emphasized the proper use of clothes closets and the care of clothes. The relation of correct posture to clothing, as developed in several States,

served further to emphasize the interrelation of the clothing and nutrition projects.

The simplicity of millinery of the present day and the fact that soft-felt hats were in vogue also made millinery work most popular and satisfying. In addition to basic instruction in selection, construction, and renovation, there was a tendency to hold 1-day meetings in the spring and in the fall for the instruction of local leaders.

Effort was made during the year to increase the variety of teaching devices in clothing work in order to reach more people. The demonstration was reported as the most common means used. Other means, such as illustrations, lectures, practice lessons, question and answer, observation, radio talks, and, to a limited degree, reference reading, were employed effectively. The illustrative material used was prepared either by the State extension specialist or under her supervision. Playlets, stressing color principles in particular, style shows, achievement day demonstrations and illustrated talks, window displays, leaflets, posters, slogans, and many other devices were used to present to the home maker suggestions for a better-clothed family.

During the year 297,245 different homes were reported in which improved clothing practices were adopted. Improved practices in clothing selection and construction were reported by 153,120 women; in renovation and remodeling, by 75,553; in millinery, by 57,158; in costume designing, by 73,822; in infant-wardrobe planning, by 22,193; and in adult-wardrobe planning, by 39,961.

HOME MANAGEMENT

Home-management extension was largely concentrated on the saving of labor in routine household tasks and making the kitchen more convenient and attractive as a place in which to work. Kitchen-improvement contests, usually county wide, were a very popular feature in 1927 and did much to turn public attention to kitchen improvement.

Step-saving kitchen arrangement, including the grouping of both large and small equipment, the selection of equipment with reference to use, labor saved, sanitation, quality, ease of cleaning, and cost, and the importance of running water, adequate light, and suitable wall and floor finishes were features of kitchen improvement which were emphasized in the publicity given

the contests and in the instruction given by county home demonstration agents to local clubs or groups of women. The economy in time, energy, and money to be gained through kitchen improvement and other phases of home-management work was constantly stressed.

Rural engineering specialists in a large number of States contributed to a very considerable degree to phases of home-management work. The establishment of water systems and sanitary disposal systems was a particularly widespread activity in which home management and rural engineering specialists cooperated with county home demonstration agents. In the Eastern States, particularly, attention in this field was directed to encouraging the installation of electric light and power systems in the homes. Indiana, Michigan, and Missouri reported the use of home convenience trucks in charge of home management and rural engineering specialists as a means of giving instruction and demonstrations in local communities. In New York, sewing-machine clinics continued to be held. Women were invited to bring their machines to the clinic held in their community, where the engineering specialist went over the principles involved and taught them how to clean, to adjust, and to repair their machines.

Household accounts and budget making, although less popular than kitchen improvement, the installation of conveniences, and the planning of household work continued to be important phases of home management work. Assistance was given also in putting into effect more efficient laundering methods.

There were 30,950 result demonstrations in phases of home management conducted by rural women and 13,822 by members of the 4-H clubs. Women reported as obtaining additional labor-saving equipment as a result of extension influence numbered 54,126, and 20,589 were reported as adopting a systematized plan of household work. There were 20,326 women who planned and rearranged their kitchens for convenience, and 14,493 adopted improved laundry practices. Accounts were kept and budgets were made by 8,175 women. The adoption of some improved practice in home management was reported from 106,677 homes.

HOUSE FURNISHINGS

House-furnishing activities centered in making the living room of the

rural home comfortable and attractive. The selection and arrangement of furniture, curtains, and draperies; the use of wall and floor finishes and coverings; and the selection and hanging of pictures received attention. In some instances the demonstrational efforts extended to the hall and porch. Home-furnishings agents discussed in more detail the principles and practices involved in decorating and furnishing the home as a whole, including floors and floor coverings, walls, ceilings, windows and window curtains, pictures, and accessories.

With girls, house furnishing started with the girl's own bedroom and its improvement. The "own your own room" clubs continued to gain in numbers in 1927 and were starting points of house-furnishing improvement in many homes. The aim of this work with girls has been not only to accomplish a few definite improvements in the girl's bedroom but to form her ideals as to what is desirable in the whole house and premises. The re-furnishing of a few articles of furniture and the addition of a clothes closet, new curtains, or a homemade rug have resulted in considerable improvement in individual bedrooms.

Incidental to the problem of making over the living room or the bedroom, there developed an extensive demand for instruction in restoring old furniture and upholstering, in reseating chairs, rug making, interior decoration, basketry, making lamp shades, and other accessories. This demand was met in a considerable degree, although, owing to the enthusiasm of individual groups of women, there was difficulty at times in keeping these minor activities subordinated to the general program for improved house furnishing. This enthusiasm for some special activity, however, helped the development of profitable home industries in a considerable number of localities and added materially to the family income. Basketry and rug making probably lead in volume of production among these home industries.

There were 33,093 result demonstrations in house furnishing conducted by rural women and 30,024 by members of the 4-H clubs in 1927. Women reported as adopting practices in the selection and arrangement of furniture, hangings, and accessories numbered 68,962; those repairing and remodeling house furnishings numbered 44,034; and those adopting practices in wall, wood-work, and floor treatment numbered 45,877. There were 126,417 homes re-

ported in which some improved practice in house furnishing was adopted.

BEAUTIFICATION OF HOME GROUNDS

Beautification of home grounds, as suggested by extension agents, met with ready response. The aim of this activity was to interest the rural family in more beautiful surroundings, such as having a clean, orderly yard, in keeping buildings and fences in good repair, and in establishing shade trees and attractive shrubbery. Yard-improvement contests on both a community and county basis met with enthusiasm and had excellent support from the press, business men, and local organizations. Points considered in such contests were (1) neatness and order of premises, (2) planting according to a plan, (3) condition of lawn, (4) permanent plantings, and (5) wise use of native plantings adapted to the locality.

With boys and girls the beautification of home grounds was an attractive supplement to productive 4-H club activities. Particularly was this true of the rural girl. The practice of agents in many sections has been to turn the attention of the girl early in her club career to the possibility of beautifying the surroundings of the home. The girl is asked to make a simple plan for the improvement of the yard around her home. In this way she gains some knowledge of the fundamental principles of simple yard planning. Some prescribed planting is done each year, building on what has been planted previously. An attempt is made to interest the girls in clean, orderly yards, with fences, steps, and buildings in good repair. Many sagging steps have been put in order, and broken gates and fences have been fixed as a result of this influence. The story is told of one woman who had begged her husband to put up a fence for 17 years but had not been successful until her two girls joined the local 4-H club and began urging it also.

The underlying motive in the beautification of home grounds has been well expressed in the statement made by one county home demonstration agent in her report. She said:

Besides the money value attached to a beautiful lawn, there is the influence of refinement upon the lives of the individuals. We are beginning to realize that premises without green-growing things look very cheerless and uninviting and that unkempt public grounds indicate lack of progress.

In some localities the growing of flowers for sale has been an interest-

ing development of this movement for the beautification of home grounds, thus making the effort income-producing as well as adding to the satisfaction of rural life.

There were 26,281 result demonstrations in the beautification of home grounds conducted in 1927 by adults and 29,824 by members of the 4-H clubs. The number of farms on which some improved practice in the beautification of home grounds was adopted was 88,839.

HOME HEALTH AND SANITATION

Health standards and household sanitation were emphasized by extension agents in 1927. In a much more limited degree attention was given to such phases of home health and sanitation as home care of the sick, personal and community hygiene, and the prenatal and postnatal care of mothers and infants. The sanitary disposal of sewage, the screening of houses, and other methods of controlling flies, mosquitoes, and other household insect pests were health and sanitation practices widely adopted. The cooperation given by negro farm families in the South deserves particular commendation. More than one-fourth of the total number of houses screened or using other methods to control household insect pests reported by extension agents were those of negroes.

The cooperation of rural engineering specialists was especially helpful in providing plans for the installation of sewage-disposal systems. The use of community tank forms and demonstration equipment in installing modern plumbing featured the cooperative work of the health and rural engineering specialists with county extension agents in Connecticut. Specialists in many other fields, including foods and nutrition, clothing, and home management, cooperated with the health specialists and county extension agents in emphasizing health aspects of their various lines of activity. Standards of community sanitation and means of achieving them were emphasized in Illinois and Missouri.

No phase of the health project is functioning more satisfactorily than in the 4-H club "growth" work which each year is increasingly recognized as an essential part of club projects. Health contests for 4-H club members were held in three States. In Mississippi, especial emphasis was placed on health contests for girls in the 4-H clubs. These contests were conducted

in cooperation with the State public health department. The county home demonstration agents arranged for free physical examinations for all girls in the 4-H clubs. County health officers, club leaders, superintendents of education, local doctors, dentists, and nurses cooperated in the project. After these examinations the girls were encouraged to correct their physical defects as far as possible by following the instructions of physicians and dentists and by adopting good food practices. There were 5,000 girls entered in the Mississippi contests.

Home health and sanitation result demonstrations were conducted by 23,421 rural women and by 56,352 members of the 4-H clubs in 1927. Sanitary closets or outhouses were installed in 7,330 homes, and cooperation was given in the placing of sewage-disposal systems on 4,088 farms. The number of homes screened because of extension influence was 12,369, and 21,093 homes used other measures to control household insect pests. Recommended health practices were reported as having been adopted in 81,545 homes and improved sanitary practices in 83,259 homes.

EASTERN STATES

The Eastern States, one of the four divisions into which the administrative work of the office is divided, include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Florence E. Ward continued as regional agent representing the office in its cooperative relations with these States.

The growing of more legume hay, and particularly of alfalfa hay, continued to be one of the major agricultural projects in this region in view of the importance of dairying as a farm enterprise. More than three-fourths of the county agricultural agents in the Eastern States were concerned with teaching farmers how to grow alfalfa. These agents reported that nearly 10,000 farmers grew alfalfa last year for the first time. Considerable emphasis, too, was placed on the growing of sweet clover for pasture.

Interest in improving the production of dairy cows was keener than ever. The number of herd-improvement associations organized increased from 171 in 1926 to 208 in 1927. Approximately 20,000 more cows were tested for production in 1927 than in 1926, and 750 more members were enrolled

in improvement associations. County agricultural agents also reported that 2,003 farmers, or 200 more than last year, were helped in obtaining purebred dairy bulls.

County agents and extension specialists continued to give State and Federal authorities whole-hearted cooperation in the eradication of tubercular dairy cows. The county agricultural agents reported that over 65,000 farmers were influenced to test their cows for tuberculosis. At the same time the agents placed greater emphasis on teaching farmers to improve their practices in the sanitary production and care of milk. The eastern region is primarily a fluid-milk area, and specialists and agents did everything possible to help farmers to produce the best. Thus in Worcester County, Mass., the extension service, in cooperation with the local milk dealers, interested the milk producers to have their milk tested by disinterested persons. Of 583 samples that were taken, 171 were found to be below the standard of cleanliness set by the board of health. The 171 farmers were visited and instructed in methods of producing better milk. They were encouraged to clean up their barns and dairies in order that these might pass inspection of the board of health. All this was done in a friendly and helpful way. As a result, the farmers and dealers agreed to sell on a weight-and-test basis, and a much better product was offered consumers.

Nine-tenths of the county agricultural agents in the Eastern States reported extension work in poultry, which indicates that this enterprise was important and second only to dairying. The control of poultry diseases and parasites has come to be a most important problem. Several of the States in this section centered their effort on "grow healthy chicks" campaigns. Such campaigns taught farmers to start with disease-free chicks and to raise them in clean houses on clean noninfested ground and to manage the grown birds so that better and more profitable pullets would be obtained. Some poultrymen succeeded in reducing their losses of baby chicks to 8 per cent, whereas the losses theretofore had been 25 and 30 per cent and upwards. County agricultural agents still emphasized the best practices in feeding and managing poultry flocks in addition to teaching better practices in rearing flocks.

The control of crop pests required more attention in 1927 from extension

agents than usual, particularly in New York and Pennsylvania. The European corn borer necessitated much intensive work, it now being present in most of the counties in New York and in 43 in Pennsylvania.

Interest continued in the development of better fruit, particularly by elimination of inferior varieties and by more effective control of insects and diseases. Much was done to improve the spray service. This project is designed to make possible local study of pests and diseases and to furnish growers timely and authentic information on spraying and methods of control. In New York State some counties employed specially trained part-time extension agents each year to carry on this work. The work in fruit growing indicates that the changing demands of the agricultural and market situations were recognized.

The work in vegetable gardening likewise showed recognition of the need for meeting changed market conditions. Vegetables from the Southern and Western States have been reaching the eastern markets in increasing quantities. The eastern grower has become interested as never before in better strains and varieties of vegetables, and the efforts of the extension agents to interest the vegetable gardener in better grading and packing is winning increasing support.

The work in potato growing still centered about the use of improved seed and the control of diseases. Nearly two-thirds of the county agents reported work in this line and 6,600 farmers were reported to have used improved seed for the first time last year. Interest in potatoes has increased in the Eastern States because of the opportunities which exist to sell them locally at good prices. Thus potatoes have come to be desirable as a cash crop for many farmers in this section.

Reforestation and the maintenance of good farm wood lots were also given increased attention by farmers in the Eastern States. About 200 county agricultural agents reported work in this line and more than 5,600 farmers were influenced to adopt recommended practices. This is an increase of nearly 1,300 farmers over last year.

The importance of the problem may be understood when it is known that since 1880 more than 50,000 farms with an area of about 4,900,000 acres have been abandoned in New York State alone. Extension agents in New

York say that probably 4,500,000 acres of this land should be reforested, for it is unsuited for farming under present conditions. So serious is the problem that appropriations have been made in two counties in New York for the employment of county extension foresters in cooperation with the extension service. During the year 7,400,000 trees were set out in this State as the result of the activities of county agricultural agents. Other States reported like interests or were awaiting the development of State nurseries to make available a cheap supply of seedling evergreens for farm reforestation.

Farm management extension work increased both in the number of counties with farm-management projects and in numbers of farms influenced. During the year much was done to help farmers interpret and use outlook material and data on the cycles through which major agricultural products pass. With this also came an increase in the use of enterprise cost accounts and business analyses to aid farmers in making needed business readjustments and to help extension workers develop extension programs based more nearly on the real circumstances and needs of farmers.

Throughout the Eastern States extension workers appreciated more fully the need for long-time agricultural programs. The fact that an extension program which is based only on production practices can not be most helpful to the farmer is gradually being recognized. States like Connecticut, Maine, Massachusetts, and New York have led in this and have begun to build programs that are based on area trends and influences as well as on farm-management precepts. Farm-management specialists have pointed out that ultimate profits are the goal and that programs of work must recommend the most profitable farm-business set-ups which certain groups of farmers should establish. In many ways the growing appreciation of the need for long-time economic programs and the thirst for more economic and farm-management data indicate a great forward step in extension work. There was an increased tendency to study the situations which farm people are facing, to examine them in the light of data on which influences are affecting various enterprises, to learn from experiences of farmers themselves what type of farm business organization is more profitable, and to offer production practices

which are known solutions to these needs.

In the field of home economics, perhaps the largest development was extension teaching in child care and management, or child guidance. This work was largely limited to the pre-school child and emphasized that proper early training is the largest element in preventing undesirable behavior problems which may arise later in the life of the child. Parents were encouraged to study child behavior and also their own behavior and to measure and correct their methods of training their children in the light of the newer knowledge of psychology.

Judging by the reports of the home demonstration agents, the extension teaching in foods and nutrition resulted in a marked increase in the number of homes influenced to adopt better practices in food preparation and preservation. Much of the work in food preparation and preservation reported was carried on to supplement the more fundamental nutrition work. One of the chief problems has been the enrollment of more mothers and children in the work or the organization of teaching methods that will influence and help the mothers who can not attend the nutrition meetings and demonstrations. Nevertheless, there is so much evidence of the far greater use of milk, vegetables, and whole cereals that extension agents are encouraged and believe that the nutrition work is influencing more rapidly larger numbers of rural people.

The work in home management still was concentrated largely on teaching rural home makers how to make kitchen work more convenient or how to save labor in routine household tasks. Kitchen contests were prominent in some States. In New Jersey specialists and agents aroused state-wide interest in making kitchens more convenient and attractive. Nearly 4,300 more homes in the eastern region were influenced in this work during the year than during the previous year.

Closely akin to this was the work carried on in cooperation with the rural engineering specialists. Home demonstration agents and rural people in the Eastern States gave increased attention to the installation of electric light, power, water, and sanitary disposal systems in the homes. Through the use of community tank forms and demonstrations of modern plumbing equipment, much was done to encour-

age and teach people to install modern comforts.

Extension work in clothing selection, design, and construction still led in terms of numbers of homes influenced. There was a tendency to place less emphasis on teaching dressmaking and more on the fundamental problems in clothing a farm family most suitably and economically. Recognition of these problems was aroused, solutions were pointed out, and such skill as is essential to success was taught.

Boys' and girls' 4-H clubs were never in a more flourishing condition than in 1927. They were excellently supported by all classes of people and enjoyed splendid financial support from local governing bodies. Seventy-six county club agents and eight assistant county club agents were employed in this area. Some States have manifested a tendency to employ assistant county club agents so that work with the girls may be carried on most effectively. The great variety of projects indicated the desire of State supervisors to meet the needs and wishes of the young people. Particularly interesting was the effort made to increase the size and volume of some of the agricultural projects carried on by the boys, notably in poultry.

Note has been made of the improvement in extension programs. Similar and noteworthy improvement was also made in extension-teaching methods. This took expression in the development of better and more detailed plans of work. Agents have begun to realize that the most effective programs of work are those that are restricted to a few well-planned, well-outlined projects which strike at the problems affecting the majority. Well-planned campaigns increased in number and showed their effectiveness not only in numbers of people reached but in time and effort saved. A great increase in the number and variety of extension means and agencies was also noted. Printed and illustrated circular letters, illustrated envelope inclosures, stickers, window displays, exhibits, and illustrative material at demonstrations and meetings were used to a much greater extent and in better ways than ever before.

During the year 281 county agricultural agents, 179 county home demonstration agents, 84 county club agents, and 251 extension specialists were employed in the Eastern States. The funds provided for extension work in

this region increased from \$4,090,472 to \$4,160,270.

CENTRAL STATES

The Central States include Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. G. E. Farrell remained in charge of administrative contacts between the office and the extension services of these States.

The year was characterized by an increase in the number of volunteer local leaders and a closer working relationship with them, the general improvement and more efficient adaptation of teaching methods to the extension field, better cooperation with business men's organizations, especially bankers' associations, better trained and more experienced agents, and a broader extension information service. These improvements were directly reflected in a wider dissemination of improved practices, more friendly and appreciative attitude toward extension activities on the part of farm men and women, and, in county agricultural agent work particularly, increased public financial support, especially from county funds.

County agricultural agents reported that increased attention was given to a thorough study of census and other economic data to furnish a more substantial background for the development of extension programs of work. Cooperation of business men's organizations and commercial clubs in furthering State and county extension programs increased. More States issued outlooks for agricultural production, which supplemented and localized the national outlook issued by the department. More attention was also given to the release of information from which could be estimated the intentions of farmers to plant crops or breed livestock. Farmers were thus enabled to plant and breed more intelligently and, to some extent, to avoid overproduction.

The increased volume of results reported by county agricultural agents, which included a 50 per cent increase in the number of farmers assisted and acres included in insect control and an 11 per cent increase in the number of boys and girls completing club projects, was attributed to the further development in number and quality of volunteer local leadership, increased financial support from county funds in practically every Central State, and

the increased efforts of better trained and more experienced agents.

In agricultural engineering the greatest advance was made in the building of hog houses, especially the portable kind used in conjunction with hog-lot-sanitation activities. The number of hog houses built in the Central States with plans furnished by county agricultural agents increased from 3,543 in 1926 to 13,362 in 1927. There were also constructed or remodeled 11,184 poultry houses, and 29,796 farms were cleared of stumps and boulders through the efforts of county agricultural agents.

The problem of obtaining high-yielding disease-free seed stocks, the prevention of damage to crops from diseases and insects, crop improvement and standardization, and legume production were principal activities in crops extension and soil improvement carried on in the Central States in 1927. The growing of sufficient feed crops for local livestock consumption was important. Alfalfa, sweet clover, and soy beans were the main crops grown for this purpose in 1927. Alfalfa retained its lead as an outstanding legume feed crop, with sweet clover a close second.

Farm management increased in popularity, due in part to the recognition of the importance of keeping accurate cost records and making analyses and in part to changes in farm management to meet corn-borer conditions. In Illinois 1,200 farm accounts were completed and analyzed, and a complete analysis of the farm business was returned to each cooperator. Agents reported that throughout the Central States 10,461 farmers kept accounts and 24,998 farmers adopted some recommended farm-management practice. In marketing activities 181,197 farmers adopted some improved practice to dispose of their farm products more efficiently and with increased profit and to purchase their supplies at a saving. Cooperative marketing associations organized during the year or previously by county agricultural agents reported that the total value of the products which they marketed in 1927 was \$122,810,057. The value of the supplies which they purchased co-operatively amounted to \$14,207,779. The total savings or increased net returns which farmers derived from membership in such associations was \$5,327,431.

Both dairying and general livestock production became more stabilized during the year because of improved mar-

ket conditions. More progress was made by extension workers in the improvement of breeding stock, use of economical feeding methods, control of insect pests and diseases of livestock, and the supplying of high-grade products to meet market requirements. In dairying, attention was centered on the elimination of unprofitable cows, the introduction of high-producing stock, growing of cheaper feeds, and tuberculosis eradication. County agricultural agents assisted 8,620 farmers in procuring purebred dairy and beef sires; 171,053 farmers were influenced to test their dairy and beef animals for tuberculosis; 21,189 to feed better balanced rations to dairy cows; 27,963 to vaccinate for hog cholera; 32,713 to feed better balanced poultry rations; and 24,455 to cull poultry.

Progress in the quality of extension activities to improve farm-home conditions was indicated by the reports of home demonstration agents in the Central States. The principal results of home demonstration efforts were (1) the increased physical welfare of farm women and girls due to improved standards of health, proper food selection, preparation, and care, better methods of personal and community hygiene and sanitation, more effective care of the sick, introduction of labor-saving home equipment, and more intelligent performance of household tasks, with periodic intervals for rest and recreation; (2) the improved economic condition of women brought about by more intelligent purchasing habits, by more efficient use of equipment, materials, time, and energy, and by carrying on activities which produced an income; and (3) the better social status of farm women which was due to an improved personal appearance, to a wider acquaintance with other women in the community, to the beautification of the interiors and exteriors of farm homes, and the inclusion of music, recreation, and social intercourse at meetings, camps, achievement days, and the like.

Home demonstration agents enrolled 59,839 women in home-economics clubs, influenced the adoption of 164,196 improved home practices, and trained 14,535 farm women to act as local leaders in promoting better home and community life in their respective communities. Probably one of the best achievements of the year was the further development and increased efficiency of local leadership.

Clothing extension activities continued to give women and girls that satisfaction which comes from the eco-

nomical purchase of materials and garments and from the knowledge that one's clothes are becoming and appropriate to the occasion. Many women learned to select their wardrobes with taste and judgment, following the principles of design and color learned through the clothing activities of the home demonstration agents. Increased interest in better-fitting shoes for all members of the family was also an outstanding phase of the 1927 reports of agents. The study of ready-made merchandise, such as dresses, undergarments, hose, shoes, and household textiles, was reported by a number of States. The simplicity of modern hats made millinery a popular and satisfying project, and many discarded hats were renovated and reconditioned and appeared as an attractive part of the farm woman's attire.

Adequate standards of nutrition for physical fitness were emphasized during the year. The need for a sufficient variety of nutritive foods in the daily diet and the necessity of considering the year's requirements of fresh and canned vegetables when planting the garden were presented to farm home makers, with the result that keen interest was aroused in food production, selection, preparation, and preservation. The consistently increasing interest in nutrition and the sustained effort for improved methods of presenting this work to the farm woman so that she may use it effectively in her daily responsibilities was one of the major contributions of home demonstration work during the year.

In home management emphasis was placed on such phases as kitchen improvement, selection of equipment and its use, and kitchen arrangement. Ohio continued the demonstration of household accounts, 70 of which were carried on during the year. In Illinois, Kansas, and Michigan a further well-defined effort was made to analyze the managerial responsibilities of the home maker. In several States kitchen improvement was carried on through contests. Conservation of the home maker's strength and wise use of her leisure time were emphasized more than ever.

Encouraging progress was also reported by home demonstration agents in such phases as home furnishing by applying the principles of good decoration in appropriate and inexpensive ways; the use of better sanitary practices, such as use of screens, good ventilation, sewage disposal, provision for bathing, pure drinking water,

eradication of rats, mosquitoes, and other pests, and general clean-up of yards; and child care and training.

Boys' and girls' 4-H club work in the Central States remained at its high standard of effectiveness in meeting the needs of the rural community, and encouraging gains were made in its growth during the year. The enrollment of boys and girls in 4-H clubs reached a new high level of 195,839 in 1927, or an increase of 5,862 over the number enrolled in 1926. Of the boys and girls enrolled, approximately 72 per cent completed all work which had been assigned to them. The enrollment comprised 115,235 girls and 80,604 boys, which indicated that a better balance was attained than in previous years.

A study of the number of boys and girls enrolled and completing their work in the various projects reveals that clothing, poultry, swine, and dairy cattle were the most popular subjects among the young people. In clothing activities 63,675 were enrolled, 22,080 in poultry clubs, 17,607 in swine clubs, and 15,610 in dairy clubs. Other important projects which received considerable attention were food preparation, in which 14,090 were enrolled, home gardens with 11,642 boys and girls enrolled, and home health and sanitation with an enrollment of 11,285.

Two projects—forestry and leadership—which are comparatively new in the Central States, showed substantial development. Forestry clubs were reported by Kentucky, Michigan, Minnesota, Ohio, and Wisconsin. Leadership activities were participated in by members already enrolled in other club projects and as supplemental work. This phase in a variety of forms was reported by nearly all of the Central States. It served as one means of providing activities for older club members about to assume the responsibility of local club leaders.

An increase in the number of demonstration teams and judging teams was reported, although the relative number of each was still largely in favor of demonstration teams. It was clearly evident that these teams were used more than ever by county extension agents to popularize 4-H club work in various sections of their counties. A noteworthy effort was made to revise club exhibits at county fairs to feature a single idea or theme which told the club story. Such exhibits were far more effective in their simple presentation than the more complicated exhibition of products so often used

as the basis of exhibits at county fairs. The establishment by county fairs of a definite boys' and girls' 4-H club department with a superintendent in charge was another indication of development in this method of presenting club work to the public. At some 1,200 community shows and fairs and at approximately 950 county, State, and interstate fairs 4-H club work was featured in public exhibits.

More attention was given to the older boys and girls of advanced club age, who showed a decided inclination to increase their interest in club work during the year. In Minnesota the father-and-son partnership plan was built around farm management work. Contracts were signed between father and son which specified definite responsibilities to be assumed by each. Thus, the boys developed active interest in farming as a business, a responsibility in the conduct of farming operations on the home farm, and the period of transition between adolescence and maturity was successfully bridged.

On June 30, 1928, there were 1,606 extension workers in the 13 Central States, including 15 extension directors and assistant directors, 833 county agricultural agents, 9 assistant county agents, and 52 supervisors of county agent work; 132 county home demonstration agents, 2 assistant home demonstration agents, and 26 supervisors of home demonstration work; 43 county 4-H club agents, 1 assistant club agent, and 62 club supervisors; and 431 extension specialists.

The total amount allotted for extension work during the fiscal year ended June 30, 1928, in the Central States was \$7,150,000. The financial trend was toward increased local support of the work from county funds. The amount raised by county appropriation was approximately \$176,000 more than the sum raised during the previous year.

SOUTHERN STATES

The Southern States include Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. J. A. Evans, assistant chief of the office, has represented the office in its cooperative relations with these States since February 1, 1928, when O. B. Martin, who was in charge prior to that date, became director of extension work in Texas.

Notwithstanding the flood in the Mississippi Valley and severe boll-weevil injury to cotton in some States

both of which adversely affected extension work, the year was one of decided progress. In the flooded area, especially in Arkansas, Louisiana, and Mississippi, extension programs were disrupted and entirely set aside and the activities of the extension forces were of necessity turned to relief and rehabilitation work in cooperation with the American Red Cross. This work took practically all the time for the entire year of agents of all classes remaining in the flooded counties and also a considerable portion of the time of the entire extension staff of these States.

It is estimated that in Louisiana the extension staff devoted a total of 6,752 working days to relief and rehabilitation work in the flooded area. Comparable time was given to this work in Arkansas and Mississippi. Although not along regular extension lines, the relief and rehabilitation work of the extension forces was of inestimable value. It is believed that the widespread distribution of improved varieties of garden seeds, soy beans, and cottonseed, made by the American Red Cross, assisted by extension forces, will serve greatly to promote future extension programs in the flooded territory, especially in home gardens, legumes, hay, and the standardization of cotton varieties.

One serious result of the flood disaster was the necessity of discontinuing the employment of a great many county agricultural, home demonstration, and men and women negro agents in the territory, on account of the utter inability of many counties to continue their financial support. Prior to the flood in these States there was demand for many more additional agents which could not be filled for lack of State and Federal funds. As soon as the Federal emergency appropriation for extension work became available, county workers were appointed in the flooded counties as rapidly as possible. On June 30, 1928, there were 2,116 extension workers employed in the Southern States, in comparison with 2,104 in 1927.

The most widespread demonstration activities were concerned with various phases of poultry husbandry, including home poultry. Demonstrations and work in this class of projects were reported in 15,779 separate communities by 1,275 agents. The horticultural projects, including home gardens and home beautification, were the next most general activity. Results from these activities were reported by 1,324

agents, and the activities were carried on in 15,465 different communities.

Various field-crop demonstrations were carried on in 13,337 communities. Following these, the projects relating to foods, rural engineering, dairy husbandry, including the home dairy, and clothing received the most widespread attention, each of them being carried on in approximately 9,000 different communities.

Considerable attention was paid to the economic production of cotton, which was still the main cash crop of the South. Adult demonstrations, contests, and boys' club demonstrations were used to illustrate the practices recommended to make cotton growing a more profitable occupation. Progress was made in the planting of improved varieties of pure seed, in community standardization for the production of of a single variety, and in influencing farmers to cooperate in marketing in order to obtain the benefits of accurate grading and classing. The proper use of fertilizers to increase yields and profits was also emphasized. Adult 5-acre cotton contests, promoted in many of the States by private agencies in cooperation with and under the supervision and direction of the extension service, served to attract wide attention to the cultural methods recommended. Many astounding yields were obtained in such contests at a very low cost per pound.

A total of 18,911 boys and 602 girls were enrolled as members of the cotton-production clubs in the various States. This was the leading boys' club activity. These 4-H club acre demonstrations were especially valuable in influencing adult farmers to adopt the cultural practices demonstrated. The results obtained on boys' cotton demonstrations were remarkable. In Mississippi, in spite of the fact that demonstrations in the flooded area were destroyed, more than 50 per cent of the 3,000 boys originally enrolled in the cotton clubs completed their demonstrations and made reports. The average yield was 1,444.44 pounds of seed cotton, yielding 505.9 pounds of lint. This was the first time in the history of the cotton-club work in this or any other State that an average of one bale of cotton per acre has been made. The average gross returns amounted to \$135.05. Some extraordinary yields were reported, the highest being that of Jarvis Watkins, of Mississippi, who had 3,620 pounds of seed cotton on his acre.

In Alabama 1,629 cotton-club members made 1 bale of cotton per acre. The average for all cotton-club members reporting in this State was 1,209 pounds of seed cotton per acre. Comparable yields were obtained in all of the other States by members of boys' cotton clubs.

Increased attention was given to the economic aspects of agriculture, especially to the factors controlling economic production and to the coordination of economic production and efficient marketing. Much practical use was made of the outlook and other economic and marketing information supplied by the Bureau of Agricultural Economics.

Cooperative buying and selling activities, which included the buying of seeds, fertilizers, and other staple farm supplies and the selling of farm products, grew remarkably. Cooperative sales of poultry, turkeys, hogs, lambs, vegetables, fruits, cotton, corn, and other crops were made in practically every State on a wider scale than ever before. The savings to farmers from cooperative buying and selling promoted and guided by extension workers amounted to an enormous total.

Demonstrations in the feeding and marketing of hogs were outstanding in many States. Such demonstrations coordinated production and marketing in a single project. Hogs were fed according to the directions of the swine specialists, and county agricultural agents and farmers were assisted in keeping definite feeding and cost records. The demonstrations were designed to show farmers that they could market corn and other feeds through hogs at a good profit. In North Carolina more than a half million dollars were added to the farmers' income by this project. Similar work was done in South Carolina and other States.

Commercial farm dairying showed phenomenal growth. The interest was so great in some sections of the South that extension efforts, instead of being centered on dairy promotion, were devoted mainly to guiding and directing the farmers who were already engaged in or about to engage in farm-dairy enterprises and to keeping the movement on a safe and profitable basis. Home-grown feeds, herd improvement, and right feeding and management were the principal objects in dairy extension work. Dairy tours to Mississippi, where the greatest development has been taking place, were conducted by both white and negro agents from other States wishing to promote dairying in their sections.

The vital problem of soil preservation and improvement was attacked from several angles. The tremendous losses occurring in the South from erosion were emphasized in every possible way. Great numbers of terracing demonstrations were conducted. Terracing schools, at which farmers were trained to do terracing, were very successful. Tours, bulletins, meetings, and all kinds of newspaper publicity were used in the effort to arouse the farmers of the South to the importance of this problem. As a result of extension activities, 1,128,042 acres of land were protected from erosion by terraces built on 40,680 separate farms. Other angles of the attack on the soil-fertility problem were concerned with the growth of legumes and cover crops and the intelligent and profitable use of commercial fertilizers. The growth of soy beans especially was emphasized, and large increases in the soy-bean acreage were obtained. In the rice-growing territory of Louisiana the soy bean has become an important hay and money crop, and the extension goal has been to obtain the planting of at least 25 per cent of all the cultivated lands in this area in soy beans each year.

Other legumes especially urged and demonstrated where suitable were alfalfa, sweet clover and other clovers, and cowpeas. In Alabama the extension service urged the planting of vetch in crop rotation and in cotton middles for soil improvement, and as a result of demonstrations and propaganda a phenomenal increase in the use of this legume was obtained. All told, 106,252 separate farmers were reported as adopting improved practices relating to legumes and forage crops as the result of this extension activity during the year.

Fertilizer demonstrations were made in connection with various cotton and corn contests promoted by commercial and other agencies in various States and in boys' club demonstrations to show the importance of proper fertilizing in the economical production of cotton and other crops. Careful records of costs were kept on all such demonstrations. Surprisingly large yields at very low costs were made in literally thousands of demonstrations conducted by both boys' club members and by farmers. Fertilizers were more liberally and intelligently used according to the instruction of county extension agents and extension specialists than ever before.

The second year of forestry demonstration work under the Clarke-

McNary Act showed greatly increased interest in preserving and protecting the farm and commercial forests of the South. Forestry result demonstrations were completed or carried on during the year, involving 116,515 acres, and 1,737 farmers were assisted in forestry management. Boys and girls were enrolled in forestry clubs in some sections of the country. The importance of forestry work was vigorously emphasized by the means of bulletins, newspaper publicity, demonstrations, and motion pictures, and in other ways.

In the women's projects, food preparation, clothing, food preservation and nutrition, household management, house furnishing, and home beautification were leading projects. Food preparation led in point of numbers engaged, 198,773 women and girls having been enrolled during the past year. There was a rapidly growing interest in home management and home furnishings, and the indications are that these will in the near future outrank clothing in numbers of women and girls interested.

One outstanding development in the women's work was the growing tendency for the nutrition and horticultural specialists to work out joint projects. The coordination of nutrition and horticultural production projects was singularly helpful to both lines of work. The economic appeal of the "live-at-home" slogan to increase home gardens, dairy cows, and poultry was greatly strengthened when the vital importance of these products in the diet of the family, especially of the growing child, was simultaneously presented. On the other hand, nutrition instruction was effective in proportion as the dietary requirements were made easily available to the farm home.

Curb markets, fostered especially by the home demonstration agents, increased in number in all the States, and in the volume of business done. In Alabama the number of curb markets has grown from 1 in 1923 to 18 in 1927. They were run continuously throughout the year, and their total sales were close to a half million dollars.

It is significant that many women and girls used the profits derived from their production and home industries enterprises to carry out some one of the home improvement and home beautification projects. Many kitchens were remodeled and improved, bedrooms and sitting rooms beautified,

homesteads planted with flowers, shrubs, and lawns, and homes provided with running water, baths, labor-saving devices, and other modern conveniences with the profits made by the women and girls from the sale of products from their home gardens, canning, home industries, poultry, and other enterprises of this kind.

Boys' and girls' club work had a striking growth during the year. The enrollment in boys' clubs was 118,011 and girls' clubs 181,211, or a total of 299,222, of whom 189,268 completed their enterprises. This is a very high percentage of completions when it is considered that in so large a portion of the southern territory the entire club program, and especially all crop-production projects, were ruined by the flood and had to be abandoned.

The outstanding feature of club work for the year was the better organization of clubs and the increased utilization of boys and girls as local club leaders. In most of the Southern States clubs were organized on the community plan. All boys and girls in club work in a community belong to a single club, divided for instructional purposes into project groups. In many of the States community clubs have been federated into county and State federations. A large part of the responsibility for the organization and conduct of the clubs, including the raising of money for prizes and trips, now rests with the club members themselves. Believing that the way to learn to do is by doing, most club leaders in the South also believe that the best way to train youth for leadership is to impose leadership responsibility upon them. Very gratifying results have so far followed the adoption of this policy.

Negro farmers did more diversified farming and participated more generally in cooperative undertakings than ever before. Negro extension agents in sections of Oklahoma and Alabama, wishing to promote dairying, organized tours of their farmers to Starkville, Miss., that they might see for themselves the prosperity of negro farmers in Mississippi who have included farm dairying in their farm enterprises. One outstanding extension event in Lowndes County, Ala., was a cooperative turkey sale in which six carloads of turkeys were handled. Approximately 90 per cent of the turkeys brought in to this sale were raised and owned by negro farmers, the majority of them tenants. Credit

for the success of this sale was given the negro agent in this county.

Perhaps the outstanding work of negro home demonstration agents was in child care, health, and sanitation in rural negro homes. Their food production and preservation work was also very successful. On the whole, the record of negro extension work for the year in all lines is a highly creditable one. Much progress was made.

County program building in cooperation with county and community commodity organizations and advisory committees was an important extension development. Under various names, county and community advisory committees or councils functioned in most of the counties in the South for the definite purpose of promoting and assisting extension work.

Extension programs were worked out cooperatively by extension agents and specialists and the local people in 27,360 separate communities during the year. Extension agents continued to cooperate closely with all general farm organizations and commodity, marketing, and other organizations, which enabled the agents to carry on work with organized groups instead of with individual farmers as never before.

Other steps taken to increase the efficiency of extension work were in systematizing and coordinating the work of the extension specialists; better organization of boys' and girls' and adult clubs; centering effort on the most vital and fundamental problems; making demonstrations more definite and conclusive; giving increased attention to the economics of agriculture; and in training agents to make more effective use of field meetings, tours, circular letters, and local and State publicity in connection with the demonstrations. Extension publicity contests conducted with the object of encouraging agents to study extension news writing for the local and State press were carried on in several States.

The outlook for extension work in the South is very bright. The legislatures of a number of the States have increased their direct appropriations for the work and liberalized the laws permitting county appropriations for the support of agents. County appropriations, except in financially impoverished areas, were more liberal than ever. The demand for agents in new counties was greater in some States than could be supplied. There was an increased demand for agricultural and

economic information and the services of extension agents and with it an increased responsiveness on the part of farmers and farm women to extension teaching.

WESTERN STATES

The Western States include Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. W. A. Lloyd continued to represent the office in its cooperative relations with these States. The amount of money from all sources devoted to extension work in the Western States increased from \$2,527,903.15 in 1926-27 to \$2,730,000 in 1927-28, and the number of extension workers from 538 to 556.

The number of communities in which extension programs were worked out cooperatively by extension agents and the people concerned increased from 4,723 during the calendar year 1926 to 5,302 in 1927, and the number of local and community leaders cooperating in forwarding the program increased from 21,995 in 1926 to 23,276 in 1927.

A most gratifying condition existed in the Western States in connection with the boys' and girls' club work. Practically all the agents showed an increase in the amount of attention to club work. The number of junior clubs increased from 4,307 in 1926 to 4,543 in 1927. The membership in organized boys' and girls' club work increased from 37,880 to 43,988, and the number completing their work increased from 26,275 to 30,700. More and more the county extension agents, both men and women, have recognized the demonstration value of club work and have made increased use of it in the development and furtherance of their agricultural and home-economics projects.

During the year continued progress was made in the development of a regional program of extension work. A regional conference of the 11 Western States was held at Reno, Nev., in July, 1927, being the fourth of a series of regional program-making conferences. The subjects considered at this conference were clothing and poultry. The plan of the conference was the same as that of those preceding and a regional program in these subjects was adopted. The phases of the regional program previously adopted are range livestock, human nutrition, major farm crops, dairying, home management, and farm management. A graphic ex-

hibit illustrating the principal phases of the regional program was made at the Transcontinental Highways Exposition held at Reno during July and August, 1927.

The development of facts as a basis of the organization of an extension program on a State, county, regional, and enterprise basis was continued. Particular progress was made in California, Montana, Nevada, New Mexico, Oregon, and Washington. Arizona, Nevada, and Wyoming took the initial steps in State fact organization as a basis of extension-program development. It has been found that enterprise committees in counties, appointed to assist in fact organization, have often continued to function in a most helpful manner with the county extension agents, as project leaders and extension committees.

During the year a beginning was made in Colorado and Montana in fact organization in connection with the development of a home program. This field, though beset by some difficulties not encountered in agriculture, made a satisfactory beginning. It hinged about the adoption of a standard for farm income and home convenience as a minimum for a satisfactory standard of living. This is believed to be a pioneer effort in this field. It is based essentially on the "minimum wage" idea which has been so useful in raising and maintaining the standard of living in the industries.

In the field of home economics the farm woman's vacation camp has made further and gratifying progress, California and New Mexico being added to the list of States holding these camps. This movement, which had its beginning in Montana, has now been adopted in seven of the Western States. No activity in the field of home demonstration work has occasioned so much favorable comment from the general public. The camps not only have afforded an opportunity for relaxation, entertainment, and organized play for the busy farm woman but also for instruction, demonstration, and leadership training. The women participating return to their homes refreshed and with an enlarged outlook and aroused civic consciousness for more and better community-improvement activities through extension work. A motion-picture film based on the camps in Idaho and Montana, entitled "Mother Takes a Vacation," was prepared by the Department of Agriculture. This has been most useful both as an entertainment feature in the camps and as a means of arous-

ing interest in new States undertaking this work.

An important development was the progress made in standardizing the preparation of projects and plans of work in the counties and their systematic organization in the State and county offices. The procedure involves the development of a written plan for every subproject phase in a county extension program. Reports on these subproject phases are made as results are obtained and are filed with the plan of work. In this manner a continuous history of the progress of each subproject phase is accumulated from year to year. This system is now in operation in California, Colorado, Montana, Nevada, Washington, and Wyoming, with two additional States in process of reorganization. It has done much to systematize and coordinate the work of the specialists with the extension program in the counties.

An interesting commentary on the public esteem in which extension work is held occurred in California when the St. Francis Dam broke and released a flood of water which brought complete or partial destruction to a large number of farms in its path. At the request of the governor, county agricultural agents were released from their work in the counties not affected by the flood for the purpose of making a survey of the damage done in the flooded area. Practically the entire county agent force was assigned to this work for several weeks and performed it in a manner satisfactory to all interests.

One of the important developments of the year was the holding of county outlook conferences in Oregon. This was a most helpful attempt to use the national and State outlook reports in assisting farmers to decide on adjustments in agriculture in advance of planting. Such county outlook conferences were held immediately after the national outlook was released. In counties having an organized economic background for their programs of work, the conferences afforded an opportunity for the review of facts and a revision of the program when necessary.

DEMONSTRATIONS ON RECLAMATION PROJECTS

Few changes occurred in the work of the office of demonstrations on reclamation projects during 1928. An extension agent was employed on the Carlsbad project in New Mexico; altogether there are 12 projects with

which this office is cooperating financially in conducting organized demonstrations. The projects are as follows: Uncompahgre, Colo.; Minidoka, Idaho; Flathead and Huntley, Mont.; North Platte, Nebr.-Wyo.; Carlsbad, N. Mex.; Newlands, Nev.; Klamath and Umatilla, Oreg.; Belle Fourche, S. Dak.; Strawberry, Utah; and Shoshone, Wyo. The agriculturist in charge has visited several other projects to keep in touch with local conditions. Conferences have been held with water users and representatives of the Reclamation Service and the State extension services, relative to better agricultural programs for the projects.

The cooperative relations with the various State extension services have been all that could be desired. Extension workers of the different States have been willing at all times to do everything possible to add to the efficiency of the work on the Federal projects. The demonstration work is being received very favorably by the settlers and is without doubt on a better basis than it has been at any previous time. Both the Reclamation Service and the water users' associations on the projects are giving it their loyal support. They feel that the transfer of the demonstration work to the Extension Service has eliminated the possibility of duplication and misunderstandings and brought about better support locally for all phases of extension work.

The field activities of the office have been conducted under definitely planned programs of work. These programs have been formulated with the aid of the local people.

CROP PRODUCTION

All phases of soils and crops have been given some attention, but special emphasis has been placed on pure seed, fertilizers, and weed eradication. The demonstrations in the use of pure seed over ordinary seed have been very convincing. Increased yields in favor of pure seed have ranged from 10 to 25 per cent with grains and as much as 50 per cent with potatoes. Not only has the use of pure seed been encouraged as a means of increasing yields, but the opportunity to build up a commercial pure-seed industry has been stressed. Already many farmers are realizing a fair share of their income from seed sales.

The campaigns on the use of green and barnyard manures seem to have been effective, at least a more liberal use of fertilizer is noticeable on several of the projects. The practice of

sowing sweet clover with small grains as a soil builder is becoming quite common. After the grain is harvested, the sweet clover is irrigated and allowed to develop some growth, then used as a fall pasture or plowed under. Frequently it is left and used the following year as a pasture for sheep or dairy cows and then seeded the second spring to small grain, mostly barley, and sweet clover. The results of this rotation have been very encouraging, and yields as high as 60 bushels of wheat and 90 bushels of barley have been reported on land which a year or two before produced not more than half these yields.

Irrigation farmers probably have no more serious problem than that of weed eradication. Those who have been studying the problem estimate that the weed toll on many irrigated farms, owing to reduced yields, is not less than 25 per cent of the acre income. Data on the exact loss due to weeds are hard to get, but the seriousness of the problem is indicated by the fact that loaning institutions refuse to make loans on lands where certain noxious weeds, such as morning glory, Canada thistle, and Russian knapweed, are prevalent.

The demonstrators have been engaged in working out practical control measures. Numerous demonstrations have been conducted in the use of chemical weed killers, most of which have been successful. The big drawback to the use of commercial weed killers has been their expense. The cost per acre is very high, depending on the material used and the spread of infestation. The chemicals thus far used in the demonstrations have been sodium chlorate, carbon bisulphate, sodium chloride, and several proprietary preparations. In addition to the work with chemicals, much time has been spent in getting farmers to cultivate infested areas every few days. Weed eradication has aroused the interest of business men as well as farmers to such an extent that in some of the counties where Federal projects are located the county commissioners have employed a full-time weed man for the summer months to work under the supervision of the county extension agent.

LIVESTOCK

The livestock work has been continued along much the same lines as last year. Dairying and poultry are still the leaders among the livestock industries. The swine industry, while

making improvement, has never regained the importance it had prior to 1920. Sheep are becoming more important each year, as evidenced by the increasing number of farm flocks and feeding pens to be seen on project farms. The farmer is more appreciative of the fact that his products must move to market in concentrated form and that bulky products should be marketed on the farm or in the locality where they are produced. Wool and lamb pools are now quite common on the projects. This has been brought about largely as a result of well-planned extension work and the untiring efforts of those engaged in it.

In furthering dairying purebred sires, sanitation, better feeding, and the elimination of the boarder cow have been stressed. Eight cow-testing associations have been organized during the year, with 2,714 cows under test. Purebred sires were obtained for 97 farmers, and 197 more were given assistance in selecting purebred females. Demonstrators induced 120 farmers to improve their feeding methods and 360 to test their cows for tuberculosis. During the year 250 dairy demonstrations were conducted, involving 1,507 animals. As a result of the dairy work 700 farmers were influenced to adopt better dairy practices along one line or another. The interest in dairying has been unusually good, though its growth has been somewhat retarded because of scarcity and high prices of stock.

Turkey production has made more growth than other lines of poultry production. The rapid increase in the size of the farm flocks has been very noticeable. A few years ago 100 or 200 turkeys on a farm were considered rather a large flock, but to-day flocks of 3,000 are to be seen on some project farms, and flocks of 1,000 are quite common.

The poultry work has been confined very largely to disease control, feeding, and marketing. One of the limiting factors in the production of poultry, especially turkeys, has been that of disease. This drawback, however, through the use of vaccines, sanitary methods, and properly prepared feeding rations, is rapidly being overcome. Good work has been done in suggesting rations to be made up of home feeds. In some communities a few years ago 80 per cent of the poultry feed was being shipped in, and now, through the efforts of the field men, most of it is being grown and mixed at home.

Marketing has been a major activity throughout the year. Farmers have

been aided in organizing cooperative associations through which many cars of eggs, live poultry, and dressed turkeys have been handled. The cooperative-marketing movement is growing more popular with the settlers, and it is receiving their support more than ever before.

MISCELLANEOUS

The annual reports show that 10,244 personal visits were made to farms by the field men, that they received 7,437 telephone calls, and that 19,010 individuals called at their offices for information. Letters written numbered 14,701 and bulletins distributed 12,317. Nearly 1,000 boys and girls carried on some type of club work, 80 per cent of whom completed the work outlined. Nearly a thousand method and result demonstration meetings, with a total attendance of 12,349, and more than a thousand other meetings, with an attendance of 38,642, were held. Other activities which were fostered by the field men were training schools for local leaders, club camps, extension schools, and short courses of various kinds.

MOTION PICTURES

The personnel of the office of motion pictures has continued the same as at the close of the previous year, except that H. B. McClure, formerly of the office of exhibits, was added to the staff on February 1, 1928. Mr. McClure has devoted considerable attention to a study of the distribution and use of the department's films, and some of the findings of his investigation are included in this report.

PUBLIC USE OF FUNDS

Appreciation by the public of the department films is indicated by the fact that 387 copies were purchased during the year by educational institutions, farmers' organizations, foreign governments, and other agencies, this being nearly twice the number purchased by the department itself for circulation. About 8,000 shipments of films were made for a total of nearly 100,000 loan days, 36,000 of which represent loans to extension workers. More than 600 applications for films were unfilled, although the department has approximately 2,000 copies of its films available for circulation and an equal number of copies have been sold to outside agencies.

The estimated attendance at showings of films lent by the department

during the year, based on accurate reports from many borrowers, is 5,000,000 persons. As the number of copies of department films in the hands of purchasers is greater than the department's own stock, it seems safe to estimate that double this number saw a department film during the year. Cost to the department for this method of presenting information to the public did not exceed a half cent per capita. Pictures in story form were in greater demand than straight educational films.

Demand for films is well distributed throughout the country. Because of the greater cost of transportation to the Western States and the longer time needed for transit, the West makes relatively fewer requests for films than do other sections, but loans to the West are for longer periods than are loans to the Eastern States. A western film producing and distributing center is needed so that better service can be given to that region.

The number of motion pictures lent to each State during the fiscal year, and the total number of days the pictures were available for use on these loans are shown in Table 1.

TABLE 1.—Number of motion pictures lent, by States, and days these pictures were available for showing on loans during the fiscal year ended June 30, 1928

State	Pictures shipped to—			Pictures available to—		
	General public	Extension workers	Total	General public	Extension workers	Total
	No.	No.	No.	Days	Days	Days
Ala.....	98	101	199	879	1,845	2,724
Ariz.....	14	8	22	665	47	712
Ark.....	35	27	62	3,554	1,169	4,723
Calif.....	83	45	128	2,266	1,108	3,374
Colo.....	152	32	184	4,655	271	4,926
Conn.....	65	2	67	117	2	119
Del.....	17	7	24	23	39	62
D. C. ¹	370	74	444	1,408	240	1,648
Fla.....	56	15	71	1,617	45	1,662
Ga.....	71	81	152	885	1,284	2,169
Idaho.....	17	5	22	269	16	285
Ill.....	252	184	436	1,818	2,393	4,211
Ind.....	106	83	189	849	810	1,659
Iowa.....	32	59	91	1,142	1,024	2,166
Kans.....	36	56	92	1,213	2,326	3,539
Ky.....	65	22	87	1,237	199	1,436
La.....	18	18	36	279	520	799
Me.....	23	32	55	75	297	372
Md.....	149	99	248	656	289	945
Mass.....	119	51	170	698	441	1,139
Mich.....	228	78	306	1,215	553	1,768
Minn.....	102	181	283	766	3,225	3,991
Miss.....	61	48	109	2,061	226	2,287
Mo.....	70	36	106	274	250	524
Mont.....	54	3	57	4,057	90	4,147
Nebr.....	31	29	60	173	472	645
Nev.....	3	19	22	22	270	292

TABLE 1.—Number of motion pictures lent, by States, etc.—Continued

State	Pictures shipped to—			Pictures available to—		
	General public	Extension workers	Total	General public	Extension workers	Total
	No.	No.	No.	Days	Days	Days
N. H.....	59	117	176	470	625	1,095
N. J.....	169	48	217	459	84	543
N. Mex.....	57	41	98	2,040	879	2,919
N. Y.....	419	107	526	2,756	1,303	4,059
N. C.....	54	100	154	613	777	1,390
N. Dak.....	28	5	33	1,258	5	1,263
Ohio.....	410	139	549	4,624	1,063	5,687
Okla.....	107	17	124	2,896	142	3,038
Oreg.....	40	22	62	1,638	2,760	4,398
Pa.....	302	136	438	1,179	416	1,595
R. I.....	7	2	9	79	38	117
S. C.....	55	105	160	395	736	1,131
S. Dak.....	7	35	42	64	2,210	2,274
Tenn.....	120	80	200	682	809	1,491
Tex.....	103	73	176	4,323	922	5,245
Utah.....	49	141	190	1,799	938	2,737
Va.....	202	343	545	3,977	938	4,915
Vt.....	35	76	111	86	703	789
Wash.....	11	16	27	222	240	462
W. Va.....	108	97	205	675	1,218	1,893
Wis.....	111	65	176	1,027	579	1,606
Wyo.....	34	22	56	594	150	744
Total.....	4,814	2,839	7,653	63,730	36,048	99,778

¹ School.

NEW FILMS PRODUCED

Twenty-two new films were completed and placed in circulation during the year, totaling 30½ reels. The following is a list of titles of these films, the number of reels, the number of copies available for circulation, and the sponsoring bureaus:

T. B. or not T. B. (Avian tuberculosis); 2 reels, 6 copies, Animal Industry.

The Beefsteak Bequest; 1 reel, 2 copies, Animal Industry.

The Barnyard Underworld; 1 reel, 7 copies, Animal Industry.

This Little Pig Stayed Home; 2 reels, 21 copies, Animal Industry.

Blood Will Tell; 1 reel, 13 copies, Dairy Industry.

Cooperative Marketing—Livestock; 2 reels, 8 copies, Agricultural Economics.

What's Ahead; 2 reels, 7 copies, Agricultural Economics.

Persimmon Harvesting and Storage in China; 1 reel, 1 copy, Plant Industry.

Soy Beans at Home; 2 reels, 2 copies, Plant Industry.

Wild Flowers; 2 reels, 1 copy, Plant Industry.

Saving the Soil by Terracing; 1 reel, 11 copies, Public Roads.

The Forest—And Health; 1 reel, 16 copies, Forest Service.

The Forest—And Wealth; 1 reel, 39 copies, Forest Service.

That Brush Fire; one-half reel, 23 copies, Forest Service.

Winged Warfare on the Boll Weevil; 2 reels, 3 copies, Entomology.

Gipsy and Brown-Tail Moths—Life History; 1 reel, 4 copies, Entomology.

Gipsy and Brown-Tail Moths—Their Insect Enemies; 1 reel, 4 copies, Entomology.
Gipsy and Brown-Tail Moths—Control Methods; 1 reel, 4 copies, Entomology.

Old Jake Wakes Up; 1 reel, 15 copies, Entomology.

Carry On; 2 reels, 7 copies, Extension Service.

How to Get Rid of Rats; 1 reel, 11 copies, Biological Survey.

Million Dollar Pockets; 2 reels, 9 copies, Biological Survey.

EXHIBITS

The office of exhibits continued during 1928 under the direction of Joseph W. Hiscox and without important personnel changes. The Washington staff at the end of the year numbered 27, an increase of 1, and the staff at the warehouse at Alexandria, Va., numbered 9. Expenditures from the regular appropriation for exhibits at agricultural fairs and expositions amounted to \$107,900, in addition to which \$7,025 was expended for a department exhibit at the World's Poultry Congress at Ottawa, \$2,500 for the preparation of an exhibit to be shown at the Ibero-American Exposition at Seville, Spain, in 1929, and approximately \$7,100 was contributed by fairs and expositions for the payment of transportation on exhibits. Total expenditures for exhibits during the year amounted to \$124,500.

Fifty-two new booths were built, 29 were revised or rebuilt, and 172 were renovated. At the end of the year 35 additional booths were under construction. Completed new construction during the year was less than during 1927, when the equivalent of 22 booths were built for the special poultry exhibit at the World's Poultry Congress.

PLANNING AND CONSTRUCTION

Light, sound, motion, and other factors were brought into play to attract attention or present facts more forcibly. Alternate flashing of red and green lights in the central feature of a forestry exhibit made the scene appear to change from a green forest to a raging forest fire. A new exhibit feature was presented at the National Dairy Show at Memphis, Tenn., which attracted much attention. This exhibit showed a barnyard with two figures representing farmers. By means of special phonograph records, power amplifier, and concealed loud speaker, these figures appeared to discuss better bulls, the production of clean milk, and the marketing of milk. As they talked they emphasized important points with appropriate gestures, the movements being synchronized with the record by a concealed operator.

In the construction of exhibits new materials are constantly being tried.

A new wall board was used during the year with unusually good results. This material is tough, has no grain, and seems to be only slightly affected by moisture. It has been largely substituted for plywood, at a considerable saving.

Frequent requests have been received from outside agencies for cooperation in the planning of exhibits. These requests, which came in the form of letters or personal calls, ranged all the way from inquiries for sources of information on the preparation and planning of exhibits to those asking for the preparation of exhibits plans or for exhibit construction. During the last two months of the year the office received 20 calls for information and advice from organizations outside the department. These requests came from farm journals, railroads, banks, and others. This is a desirable type of work which could well be expanded if funds and personnel were available.

New exhibits completed during the year were as follows:

	Booth equivalent
Butter-price curve-----	1
Dairy farm success-----	1
Dairymen's dollar-----	1
The dialogue of better dairying-----	2
Good cows are the basis of success-----	1
Market news-----	1
Some factors affecting the fertility of dairy cattle-----	2
The under—the source of a billion- dollar industry-----	1
Dairy market information-----	1
Dairy products standardization-----	1
Skim-milk powder-----	1
Conservative grazing-----	2
Current market news-----	1
Farm horseshoeing-----	2
Hog-cholera control-----	1
Livestock outlook-----	1
Methods of cooking beef-----	1
Soy beans in pork production-----	2
Self-feeding sows and litters-----	2
Soy-bean varieties for the United States-----	1
Sweet-clover pasture-----	1
The place of sheep on the farm-----	1
United States official standard beef grades-----	2
The service of livestock to mankind-----	1
European corn borer (3)-----	1½
Health sticks to clean chicks-----	1
Farm forestry pays-----	1
Cooperative marketing-----	1
Fires kill trees and rob soil-----	1
4-H club exhibits:	
Heart-----	1
Head-----	1
Hand-----	1
Health-----	1
Center feature-----	1
Save your corn (corn-borer exhibits, 7)-----	1½
Saving fruit from frost-----	1
Federal aids highways (eastern)-----	1
Dual-purpose trees-----	1
Grow timber-----	1
Ground squirrels-----	1
Federal-aid highways where traffic is heaviest (eastern)-----	2
Total-----	52

SHOWINGS IN 1928

Exhibits were displayed during the fiscal year at 76 fairs and expositions throughout the United States. These showings included many of the impor-

tant State fairs, the International Livestock Exposition, the National Dairy Show, the American Royal Livestock Show, the Chemical Industries Exposition, and numerous miscellaneous showings.

List of exhibitions held during the fiscal year ended June 30, 1928

Place	Occasion	Date
Amherst, Mass.	Farm and Home Week	July 26-29, 1927.
Amarillo, Tex.	Tri-State Fair	Sept. 12-18, 1927.
Ann Arbor, Mich.	Open House of University of Michigan	Mar. 23-24, 1928.
Aurora, Ill.	Central States Exposition	Aug. 12-19, 1927.
Austin, Tex.	Missouri Pacific Better Health Special	Jan.-Feb., 1928.
Baltimore, Md.	B. & O. Centenary Exposition	Sept. 24-Oct. 8, 1927.
Do	B. & O. Better Dairy Sires Special	Oct. 31-Nov. 18, 1927.
Do	B. & O. Poultry Special	Mar. 4-24, 1928.
Birmingham, Ala.	Alabama State Fair	Sept. 26-Oct. 1, 1927.
Brockton, Mass.	Brockton Fair	Oct. 4-8, 1927.
Charlottesville, Va.	Dairy Convention Show	Jan. 16-20, 1928.
Chicago, Ill.	International Livestock Exposition	Nov. 26-Dec. 3, 1927
Do	American Farm Bureau Exposition	Dec. 5-7, 1927.
Cleveland, Ohio	National Dairy Exposition	Oct. 24-29, 1927.
Do	Cleveland Road Show	Jan. 9-13, 1928.
College Park, Md.	Farmers' Day	May 25-26, 1928.
Do	Poultry Day	June 8, 1928.
Columbia, S. C.	South Carolina State Fair	Oct. 17-22, 1927.
Columbus, Ohio	Ohio State Fair	Aug. 29-Sept. 3, 1927.
De Land, Fla.	Volusia County Fair	Feb. 14-18, 1928.
Denver, Colo.	National Western Stock Show	Jan. 14-21, 1928.
Detroit, Mich.	Michigan State Fair	Sept. 5-10, 1927.
Des Moines, Iowa	Iowa State Fair and Exposition	Aug. 24-Sept. 3, 1927.
Donaldsonville, La.	South Louisiana Fair	Oct. 16-23, 1927.
Douglas, Wyo.	Wyoming State Fair	Sept. 13-17, 1927.
Elmira, N. Y.	Erie Better Bulls Special	Sept. 26-Oct. 8, 1927.
Elsmere, Del.	Delaware State Fair	Sept. 5-10, 1927.
Flemington, N. J.	Hunterdon County Fair	Aug. 23-27, 1927.
Florence, S. C.	Atlantic Coast Line Livestock Train	June 15-July 15, 1928.
Forcyce, Ark.	Tri-County Fair	Oct. 5-8, 1927.
Grand Rapids, Mich.	West Michigan State Fair	Sept. 19-24, 1927.
Hamline, Minn.	Minnesota State Fair	Sept. 3-10, 1927.
Kansas City, Mo.	American Royal Livestock Show	Nov. 12-19, 1927.
Do	Kansas City Auto Show	Feb. 11-18, 1928.
Leesburg, Va.	Loudoun County Fair	Sept. 7-9, 1927.
Lincoln, Nebr.	Nebraska State Fair	Sept. 4-9, 1927.
Little Rock, Ark.	Missouri Pacific Dairy Special	Mar.-Apr., 1928.
Los Angeles, Calif.	Western Road and Equipment Exposition	Mar. 7-11, 1928.
Macon, Ga.	Georgia State Fair	Oct. 13-22, 1927.
Memphis, Tenn.	National Dairy Exposition	Oct. 15-22, 1927.
Milwaukee, Wis.	Wisconsin State Fair	Aug. 28-Sept. 3, 1927.
Montgomery, Ala.	State Fair of Alabama	Nov. 7-13, 1927.
Muskogee, Okla.	Oklahoma Free State Fair	Oct. 1-8, 1927.
New York, N. Y.	Chemical Industries Exposition	Sept. 26-Oct. 1, 1927.
Do	Madison Square Garden Poultry Show	Jan. 18-22, 1928.
Northampton, Mass.	Tri-County Fair	Oct. 4-6, 1927.
Oakland, Calif.	California Dairy Show	Nov. 14-19, 1927.
Omaha, Nebr.	Omaha Sportsmen's Show	Apr. 18-21, 1928.
Orlando, Fla.	Southern National Poultry Show	Dec. 7-10, 1927.
Phoenix, Ariz.	Arizona State Fair	Nov. 7-12, 1927.
Prescott, Ariz.	Northern Arizona State Fair	July 1-4, 1927.
Pueblo, Colo.	Colorado State Fair	Sept. 5-10, 1927.
Puyallup, Wash.	Western Washington Fair	Sept. 19-25, 1927.
Reno, Nev.	Transcontinental Highways Exposition	June 25-Aug. 1, 1927.
Richmond, Va.	Virginia State Fair	Oct. 3-8, 1927.
Rison, Ark.	Cleveland County Fair	Sept. 28-Oct. 1, 1927.
Rochester, N. Y.	Rochester Exposition	Sept. 5-10, 1927.
Sioux City, Iowa	Midwestern Tuberculosis Conference	Apr. 27-28, 1928.
Spokane, Wash.	Spokane Interstate Fair	Sept. 5-10, 1927.
Springfield, Mass.	Eastern States Exposition	Sept. 18-24, 1927.
Syracuse, N. Y.	New York State Fair	Aug. 29-Sept. 3, 1927.
Tampa, Fla.	South Florida Fair and Gasparilla Carnival	Jan. 1-Feb. 11, 1928.
Trenton, N. J.	Tuberculosis Eradication Conference	Jan. 9-14, 1928.
Do	Health Show	Mar. 5-8, 1928.
Do	Trenton Interstate Fair	Sept. 26-Oct. 1, 1927.
Tulsa, Okla.	Tulsa State Fair	Sept. 24-Oct. 1, 1927.
Do	Southern Hardware Co.	Mar. 1-15, 1928.
Waco, Tex.	Texas Cotton Palace	Oct. 22-Nov. 6, 1927.
Washington, D. C.	Fourth Annual Industrial Exposition	Mar. 12-17, 1928.
Do	Catholic University May Day Celebration	May 15, 1928.
Do	American Society of Agricultural Engineers	June 19-22, 1928.
Waterloo, Iowa	Dairy Cattle Congress	Oct. 22-Nov. 6, 1927.
West Baden, Ind.	National Crushed Stone Association	Jan. 16-29, 1928.
Wheeling, W. Va.	West Virginia State Fair	Sept. 3-10, 1927.
Wichita, Kans.	Southwest Road Show and School	Feb. 21-24, 1928.
Yakima, Wash.	Washington State Fair	Sept. 12-17, 1927.

Fifteen exhibition groups were on circuit during the year, material for the exhibitions being selected with special reference to the agriculture of the areas in which they were shown. The exhibits represented dairying, livestock, marketing, farm management, weather, home economics, and boys' and girls' club work. Outgoing shipments from the Alexandria warehouse consisted of 25 carload and 34 less-than-carload movements. Fairs and expositions cooperated by furnishing free space, supplying trucks and labor for the handling, installation, and dismantling of exhibits, and making deposits to cover transportation costs. The value of this cooperation is estimated at not less than \$25,000.

Rearrangement of exhibits stored at the Alexandria warehouse has aided in the handling of an increased volume of work without additional personnel. The installation of inexpensive power-operated tools in the warehouse shop has effected a saving of personnel time and the salvaging of much used material for the preparation of new exhibits and shipping crates. Centralization of responsibility at the warehouse has resulted in more rapid handling of the work and increased output without additional labor.

INTERNATIONAL EXPOSITIONS

A special congressional appropriation of \$20,000 was made available for participation in the Third World's Poultry Congress at Ottawa, Canada, July 27 to August 4, 1927. The exhibit consisted of two carloads of material which, when displayed, occupied a space 40 by 80 feet in the central portion of the exposition building. It was highly commended by officials of other governments, the press, and prominent visiting poultrymen. Attendance at the exposition was estimated at 115,000. Delegates were registered from 42 countries, 42 States of the United States, and from 9 Provinces of Canada. More than 3,000 persons were in attendance from the United States.

The department has been allotted \$15,000 for the preparation of an exhibit to be shown at the Ibero-American Exposition at Seville, Spain, March 15 to October 12, 1929. Space 26 by 80 feet in the center of the United States exhibition building has been assigned to the department. The important facts regarding the principal crops and livestock enterprises of the United States will be portrayed. The exhibit will consist principally of grades and standards of farm products, maps, charts, bromide enlargements, and models.

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MONDAY, DEC. 10, A.M.

DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE FEDERAL HORTICULTURAL BOARD

UNITED STATES DEPARTMENT OF AGRICULTURE,
FEDERAL HORTICULTURAL BOARD,
Washington, D. C., August 31, 1928.

SIR: I submit herewith an executive report covering the administration of the plant quarantine act for the fiscal year ended June 30, 1928.

Respectfully,

C. L. MARLATT, *Chairman.*

Hon. W. M. JARDINE,
Secretary of Agriculture.

INTRODUCTION

REORGANIZATION

Under the direction of the Secretary of Agriculture, plans were fully worked out during the past year to bring all plant quarantine and related regulatory and control activities of the department under a new organization to be designated as the plant quarantine and control administration. The details of this reorganization as to appropriations and language were incorporated in the estimates for the Federal Horticultural Board, the Bureau of Entomology, and the Bureau of Plant Industry for the fiscal year 1929, and became effective July 1, 1928.

This reorganization involved particularly the Federal Horticultural Board and the Bureau of Entomology, and to a slight extent work hitherto conducted by the Bureau of Plant Industry. Two main purposes were in view in this reorganization: (1) Better administration by bringing together into one unit all the activities of the department which deal with the regulation and control of movement of plants and plant products on account of insect pests and plant diseases, and (2) relief for the research Bureaus of Entomology and Plant Industry from the growing volume of regulatory duties of this nature.

With respect to the first of these purposes, it will be recalled that the plant regulatory work under domestic quarantines promulgated under the plant quarantine act has been distributed to the Federal Horticultural Board and,

in cooperation with the board, to the Bureaus of Entomology and Plant Industry. The Bureau of Entomology has been charged with the detailed administration of very large regulatory appropriations coming respectively under the quarantines on account of gipsy and brown-tail moths, Japanese and Asiatic beetles, the European corn borer, and the Mediterranean fruit fly in Hawaii. The only appropriation to the Bureau of Plant Industry which involved regulatory and control work was concerned with the enforcement of the white-pine blister-rust quarantine. In the administration of these quarantine and control subjects, these bureaus have acted as agents for the board. In other words, the determination of quarantines and the regulations thereunder and the general administration was by the board under the authority of the plant quarantine act. The burden, however, of field administration and of personnel and accounting was carried by these bureaus. While this arrangement has been fairly satisfactory in the past, it necessarily results in a certain division of authority which in general is undesirable. As already indicated, a much more important objection is the recognition, which has become general in recent years, that the existing situation was gradually absorbing much of the time and interest of important research personnel. Men who from training and experience were competent to do good research work were being constantly drafted into the administration of quarantine and regulatory work. This re-

organization will, therefore, relieve these bureaus of this handicap, to the great benefit of research activities.

These changes and redistributions of appropriations have in themselves involved no increase in the appropriations concerned, direct shifts having been made of both appropriation items and personnel. The redrafting of the appropriation units both for the Bureau of Entomology and the plant quarantine and control administration was the subject of very careful study by the bureaus concerned and by the solicitor and the Budget officer of the department, and the new language and authority thereunder is believed to be a great improvement over the old language of corresponding appropriations which had grown up piecemeal and lacked uniformity or logical arrangement. In the case of the plant quarantine and control administration, the plan of subappropriations was adopted which will enable the Secretary of Agriculture, under the provision for interchange of appropriations, to meet emergencies arising from new or dangerous pests such as, for example, the emergency occasioned by the spread of the Mexican fruit worm into Texas last year. Under the old system of appropriations for the Federal Horticultural Board, there was no possibility whatever of such adjustments, except by action of Congress. This feature alone may be of very large value in the case of any similar emergency which may arise in the future.

This reorganization increases very much the volume of administrative work under the new plant quarantine and control administration, bringing that appropriation up to \$2,971,050 for the fiscal year 1929. This does not include, however, a special appropriation of \$5,000,000 for quarantine and control work on account of the pink bollworm with the object discussed elsewhere in this report, nor of any appropriation which may later be made on account of the corn borer under the act that was passed at the first session of the present Congress authorizing such appropriation.

In addition to the plant quarantine and regulatory duties which come under the authority of the plant quarantine act of 1912 and the related Mexican border act, the new plant quarantine and control administration will be charged with the enforcement of the insect pest act of 1905 and, in cooperation with the Post Office Department, of the terminal inspection act of 1915, and with the act (1926) authorizing the inspection and certification of exports

to meet the sanitary requirements of foreign countries.

FEDERAL PLANT QUARANTINE BOARD

In connection with the reorganization and bringing together into one unit of all the plant quarantine and regulatory activities of the department, the act making appropriations for the Department of Agriculture for the fiscal year 1929 provides that, "* * * Hereafter the functions of the Federal Horticultural Board shall devolve upon and be exercised by the Plant Quarantine and Control Administration, the chief of which shall serve ex officio as chairman of an advisory Federal Plant Quarantine Board of five members, the four additional members to be designated by the Secretary of Agriculture from existing bureaus and offices of the Department of Agriculture, including the Bureau of Entomology, the Bureau of Plant Industry, and the Forest Service, and who shall serve without additional compensation." This action therefore retains the principle of an advisory board but under a more appropriate title.

AMENDMENT TO THE PLANT QUARANTINE ACT

An amendment to section 10 of the plant quarantine act of great importance to its future enforcement received Executive approval and became effective May 1, 1928. This amendment gives authority, hitherto lacking, to stop and—without warrant—to inspect, search, and examine persons, vehicles, receptacles, boats, ships, or vessels, and to seize and destroy or otherwise dispose of plants and plant products or other articles found to be moving or to have moved in interstate commerce or to have been brought into the United States in violation of the act or of any quarantine order thereunder. The need for such amendment has been felt throughout the whole period of enforcement of the plant quarantine act and has become especially imperative in connection with the enforcement of such domestic quarantines as those on account of the European corn borer, the Japanese beetle, the pink bollworm, and the white-pine blister rust. It is a perfectly natural and frequent habit for motorists and others to pick up in the course of their trips, articles the movement of which is prohibited or restricted on account of these or other pests and carry them long distances—frequently interstate. The present habit of farm roadside stalls for the sale of farm produce has led to a

great deal of unwitting violation of certain of these quarantines, which has been controlled by road stations very largely; but every now and then some individual comes along who refuses to stop or who questions the authority to make inspections and seizures. This new authority will also be of great service in the enforcement of foreign quarantines at ports of entry. Hitherto it has been impossible, legally, to stop the entry of contraband articles or to have them destroyed except through the cooperation of the customs service.

WORK OF THE YEAR

Under the present organization of the Federal Horticultural Board the work of the year as herein reported deals (1) with the branch of foreign plant quarantines, with which is incorporated a report on export certification, and (2) the branch of domestic plant quarantines, more particularly those relating to the control of important pests such as the corn borer, the Japanese beetle, the white-pine blister rust, etc.

The tables included in this report have been carried in the annual reports of this board over a considerable series of years and constitute a continuing record, not available elsewhere, of distinct reference value. One series of these tables gives a summary of the results of the enforcement of the various quarantines in the interception and exclusion from the United States of important new crop pests—insect and disease. Other tables record the importations of the plants and plant products, the entry of which is restricted and safeguarded under the various foreign quarantines.

As indicated in previous reports, the quarterly Service and Regulatory Announcements published by the board constitute a permanent record of the new quarantines and of revisions and modifications of those already in force. The final number of these announcements for each year contains a complete annotated list of the current quarantines, domestic and foreign, as well as of other restrictive orders.

FOREIGN PLANT QUARANTINES

The enforcement of the restrictions on the entry of plants and plant products under the various foreign quarantines which have been promulgated by the department for the purpose of excluding new and dangerous pests to American agriculture is under the general direction of E. R. Sasscer.

In this work, which is performed by inspectors and collaborators of the board stationed at the more important ports of entry, the board has received excellent cooperation from the Customs Service and the Post Office and State Departments.

Descriptive matter relating to the various foreign quarantines and regulatory orders enforced in the manner described above is available elsewhere, and hence these quarantines are not discussed in this report, other than the summary which has been given yearly of new quarantines and amendments of old quarantines, page 41. Following the practice of former years, the record of inspection work performed at ports of entry and elsewhere in the United States in the enforcement of foreign quarantines and of the importation of restricted plants and plant products follows.

PLANT-QUARANTINE INSPECTION

The enforcement of foreign-plant quarantines and regulatory orders at maritime, interior, and Mexican border ports of entry involves: (1) The inspection of vessels arriving at ports of entry from foreign ports and from Porto Rico and Hawaii; (2) the inspection and disposition of all plants and plant products under restriction found in passengers' baggage by the United States customs officials; (3) the inspection of all plants and plant products, including nursery stock, seeds, bulbs, fruits, and vegetables entered under permit from all foreign countries and localities and certain products arriving from domestic territory; (4) disinfection (fumigation or sterilization) of cotton and broomcorn and other products requiring such treatment as a condition of entry; (5) inspection, in cooperation with customs and post-office officials, of restricted plants and plant products arriving by foreign parcel post; (6) inspection of plants and plant products introduced by the Department of Agriculture and all plants imported under special permit in accordance with the provisions of regulation 14, quarantine 37; (7) inspection of plants (domestic) entering and leaving the District of Columbia; (8) inspection of plant-introduction gardens of the Bureau of Plant Industry; and (9) inspection of fruits and vegetables in the field and at the point of shipment in Porto Rico and Hawaii in accordance with the provisions of quarantines 58 and 13, respectively. In addition, this service inspects and certifies export fruits and vegetables to meet the sani-

tary requirements of certain foreign countries, and at certain ports assists flour exporters by inspecting the holds of vessels and warehouses for the presence of stored-grain insects. The more important features of this inspection work are summarized below.

MEXICAN BORDER SERVICE

Inspectors are now stationed at the following 10 ports of entry along the Mexican border: Brownsville, Hidalgo, Laredo, Eagle Pass, Del Rio, and El Paso, Tex.; Douglas and Nogales, Ariz.; and Calexico and San Ysidro, Calif. Three additional ports, namely, Rio Grande, Roma, and Presidio, have assumed importance from a plant-quarantine standpoint during the year, as a result of the construction of bridges connecting these ports with Mexican towns. Pending the assignment of inspectors to these ports, the problems are now being handled by the customs service. The construction of new bridges and the constant arrival in the markets of Mexican towns on the border of fruit infested with the Mexican fruit worm have

greatly increased the problems on the border, necessitating an enlargement of the force at several of the ports.

At the seven ports having rail connections with Mexico a total of 41,193 cars was inspected in the Mexican railway yards. Of these cars, 37,939 entered the United States, 17,597 of which were fumigated as a condition of entry. Three thousand one hundred and ninety-four cars were found to be contaminated with cottonseed and were required to be cleaned before entry was permitted. A charge of \$4 is made for each car fumigated, and all fees collected are turned into the Treasury as miscellaneous receipts.

Arrangements were completed on March 15, 1928, for the fumigation of certain cars originating in the interior of Mexico, returning via the Nacozari Railroad and entering through the ports of Douglas and Naco, Ariz. In the absence of car-fumigation houses, only the interiors of these cars are fumigated. The inspectors at Douglas have performed the necessary inspections and fumigations at Naco.

A summary of the car inspection and fumigation is given in Table 1.

TABLE 1.—*Inspection and fumigation of railway cars crossing the border from Mexico, fiscal year 1928¹*

Port	Cars inspected	Cars with cottonseed	Cars entered	Cars fumigated	Fees collected
Brownsville.....	305	63	305	229	\$916.00
Douglas.....	² 1,236	86	1,236	17	68.00
Eagle Pass.....	3,047	960	2,455	2,430	9,700.00
El Paso.....	15,293	655	14,496	3,679	14,692.00
Laredo.....	10,088	1,134	8,645	8,406	33,208.00
Naco.....	48	2	48	12	48.00
Nogales.....	11,176	294	10,754	2,824	11,520.00
Total.....	41,193	3,194	37,939	17,597	³ 70,152.00

¹ This table does not include the work performed at Del Rio, Tex., since there is no railway connection with Mexico at that point. Inspectors at this port inspected 27,729 vehicles of various descriptions, 11 of which were fumigated as a condition of entry, and fees amounting to \$5.50 were collected and turned into the Treasury.

² Does not include 1,486 Mexican gondolas which crossed to the smelter, unloaded, and returned to Mexico.

³ The apparent discrepancy in the fees collected and the number of cars fumigated may be explained by the fact that it is customary for the railroads to purchase fumigation coupons in advance.

In addition to the inspection and fumigation of railway cars and vehicles entering from Mexico, the inspectors of the board cooperate with the customs service in the inspection of baggage, personal effects, and express packages from the same country. Parcel-post packages from Mexico are inspected in cooperation with the customs service and Post Office Department. During

the year, 76,243 pieces of baggage and 5,588 parcel-post packages were examined. These inspections resulted in the interception of large numbers of prohibited plants and plant products, many of which were infested with the Mexican fruit worm and other injurious insects. An itemized list of these interceptions is included in Table 2.

TABLE 2.—*Contraband plants and plant products intercepted at Mexican border ports, fiscal year 1928*

Commodity	Brownsville		Del Rio		Douglas		Eagle Pass		El Paso	
	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number
Apples.....	163	1,057	10	45	96	176	104	336	414	1,476
Apricots.....	10	49	2	303	11	130	3	120	2	33
Avocados.....	315	1,383	23	59	-----	-----	116	526	286	944
Avocado, seeds.....	35	127	6	31	-----	-----	41	255	94	374
Banana plants.....	7	31	-----	-----	-----	-----	-----	-----	2	4
Cherimoyas.....	10	24	-----	-----	-----	-----	-----	-----	45	74
Cherries.....	1	8	-----	-----	-----	-----	-----	-----	-----	-----
Corn, ears.....	-----	-----	-----	-----	-----	-----	-----	-----	113	580
Corn, pounds.....	109	1,091	24	107	35	300	29	174	55	288
Cotton bolls.....	24	103	-----	-----	-----	-----	1	2	24	173
Cotton lint, pounds.....	16	36	-----	-----	1	1	2	14	52	62
Cottonseed, pounds.....	10	3	13	1	1	1	5	24	24	19
Dates.....	2	51	-----	-----	-----	-----	-----	-----	-----	-----
Figs.....	2	5	4	40	1	120	60	1,115	41	1,090
Grapefruit.....	65	330	1	1	5	8	6	7	11	75
Guavas.....	51	348	5	26	-----	-----	16	230	115	599
Mamey.....	54	101	4	19	-----	-----	13	23	226	390
Mangoes.....	113	320	8	34	19	38	42	134	277	883
Oranges.....	352	1,372	48	97	220	599	212	524	768	2,594
Papayas.....	10	15	-----	-----	-----	-----	-----	-----	9	20
Peaches.....	63	300	14	279	15	149	22	278	112	1,138
Pears.....	54	253	1	3	19	81	19	44	218	1,580
Plants.....	185	1,350	26	184	48	482	62	540	182	1,281
Plums.....	10	41	3	27	8	27	-----	-----	23	380
Pomegranates.....	51	263	6	9	9	19	37	406	71	258
Potatoes.....	23	537	4	16	-----	-----	42	464	246	3,319
Quince.....	58	175	4	32	34	51	37	251	130	332
Sapotes.....	-----	-----	-----	-----	-----	-----	-----	-----	28	96
Sugar cane.....	64	331	48	116	53	78	62	306	223	338
Sweet limes.....	19	84	1	7	25	41	11	66	113	754
Sweet potatoes.....	9	146	3	29	37	268	22	189	82	867
Tangerines.....	10	15	-----	-----	-----	-----	-----	-----	7	37

Commodity	Hidalgo		Laredo		Nogales		San Ysidro		Total	
	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number
Apples.....	128	455	397	1,479	137	486	639	3,062	2,088	8,572
Apricots.....	-----	-----	14	379	25	1,089	123	1,018	190	3,121
Avocados.....	165	1,108	492	3,613	26	71	26	52	1,449	7,756
Avocado, seeds.....	59	161	45	219	3	11	2	16	285	1,194
Banana plants.....	1	1	3	8	-----	-----	-----	-----	13	44
Cherimoyas.....	1	2	41	66	5	5	-----	-----	102	171
Cherries.....	-----	-----	-----	-----	2	200	9	228	12	436
Corn, ears.....	-----	-----	-----	-----	-----	-----	-----	-----	113	580
Corn, pounds.....	38	228	85	369	154	1,137	32	558	561	4,252
Cotton bolls.....	15	44	2	4	3	16	6	121	75	463
Cotton lint, pounds.....	12	19	19	68	11	16	1	3	114	219
Cottonseed, pounds.....	13	519	4	40	6	10	1	2	77	619
Dates.....	3	281	-----	-----	50	1,967	2	120	57	2,419
Figs.....	9	195	112	2,216	51	582	46	671	326	6,034
Grapefruit.....	150	732	22	72	26	102	82	490	368	1,817
Guavas.....	23	158	229	1,175	12	76	1	2	452	2,614
Mamey.....	33	58	86	226	2	5	-----	-----	418	822
Mangoes.....	43	108	233	834	123	535	115	383	973	3,269
Oranges.....	391	1,836	1,038	3,307	426	1,784	1,620	11,102	5,075	23,215
Papayas.....	1	1	3	7	-----	43	-----	-----	35	86
Peaches.....	30	185	118	1,633	40	280	308	2,996	722	7,250
Pears.....	50	134	157	597	24	133	135	909	677	3,734
Plants.....	144	1,362	323	3,895	153	718	117	718	1,240	10,530
Plums.....	1	12	32	476	28	512	152	1,895	237	3,870
Pomegranates.....	44	100	120	526	106	357	6	17	450	1,955
Potatoes.....	34	205	77	2,446	1	2	40	224	407	7,213
Quince.....	61	168	168	551	7	284	3	12	572	1,856
Sapotes.....	8	40	7	27	-----	5	-----	-----	45	168
Sugar cane.....	53	306	111	312	94	446	12	45	720	2,278
Sweet limes.....	13	69	172	1,799	46	279	-----	-----	400	3,099
Sweet potatoes.....	10	36	24	175	46	261	3	21	236	1,992
Tangerines.....	27	148	1	3	-----	-----	28	161	73	364

In addition to the large quantities of certain fruits and vegetables which are entered for local consumption under the permit issued to the inspector in charge for this purpose, there has been a constant increase in carload shipments of these commodities under commercial permit to interior points. During the fiscal year 4,982 cars of Mexican bananas entered. Four thousand five hundred and ninety-two of these cars came through the port of El Paso, Tex. At Nogales, Ariz., 5,753 cars of tomatoes, peas, melons, and other vegetables, consigned to various points in the United States, were inspected and permitted entry.

MARITIME PORT INSPECTION

SHIP INSPECTION

As in previous years, vessels arriving from foreign ports as well as from Porto Rico and Hawaii were boarded promptly upon arrival and a search was made for contraband plants and plant products in the staterooms, ice-boxes, fruit and vegetable lockers,

and passengers' and crews' quarters. To perform this work full-time inspectors have been stationed at the more important ports of entry, with the exception of those located in California, Florida, Alabama, Mississippi, Georgia, Hawaii, and several ports in Porto Rico. Inspection at these ports has been very efficiently performed by State and Territorial officials serving as collaborators of the board, at a trivial cost to the department. All passengers' baggage arriving from foreign ports was examined by customs inspectors, and that found to contain plants or plant products was referred to the board's representatives for disposition. Passengers' baggage arriving from Hawaii and Porto Rico was inspected by representatives of the board for contraband plants and plant products.

Table 3 indicates, by ports, the number of ship arrivals, ship inspections and those carrying contraband plants or plant products, either in passengers' or crews' baggage, stores, cargoes, or passengers' or crews' quarters.

TABLE 3.—*Ships inspected during fiscal year 1928*

Port	From foreign ports						From Hawaii						From Porto Rico					
	Direct			Via United States ports			Direct			Via			Direct			Via		
	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband
Astoria.....	376	199	161	1,348	136	32	3	3	3	10	8	1	0	0	0	0	0	0
Baltimore.....	727	593	284	715	625	251	1	1	0	0	0	0	0	19	7	20	19	4
Boston.....	1,357	1,124	703	264	201	68	0	0	0	0	0	0	17	17	5	1	1	0
Charleston.....	228	226	107	65	65	22	0	0	0	0	0	0	0	0	0	0	0	0
Chicago.....	6	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit.....	1,042	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galveston.....	385	385	267	496	257	71	0	0	0	3	3	0	9	9	9	9	8	5
Gulfport.....	10	10	0	31	31	0	0	0	0	0	0	0	0	0	0	0	0	0
Houston.....	190	189	27	581	499	4	0	0	0	0	0	0	3	3	0	0	0	0
Honolulu.....	171	171	73	51	51	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonville.....	150	150	94	157	157	48	0	0	0	0	0	0	10	10	3	1	1	0
Key West.....	1,190	1,190	304	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami.....	908	908	261	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobile.....	339	339	185	397	387	61	1	1	1	0	0	0	5	5	4	12	12	0
Newport News.....	66	38	38	450	121	115	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans.....	1,992	1,991	1,257	139	134	77	10	10	6	0	0	0	9	9	3	2	2	1
New York.....	4,830	3,955	2,118	863	777	334	0	0	0	0	0	0	189	177	96	114	105	57
Norfolk.....	401	217	93	1,150	585	194	0	0	0	0	0	0	0	0	0	17	9	0
Pascagoula.....	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pensacola.....	99	99	22	181	181	10	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia.....	1,394	913	672	1,271	835	416	0	0	0	0	0	0	32	31	23	1	1	0
Portland, Oreg.....	187	187	90	397	397	208	0	0	0	0	0	0	0	0	0	0	0	0
Providence.....	60	21	19	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Diego.....	1,195	1,195	36	62	62	0	62	62	11	0	0	0	0	0	0	0	0	0
San Francisco.....	646	646	108	1,154	1,154	163	228	228	61	0	0	0	1	0	0	2	2	0
San Pedro.....	2,001	2,000	104	255	254	4	84	84	30	69	69	16	1	1	0	0	0	0
Savannah.....	120	97	57	182	77	36	0	0	0	0	0	0	3	3	1	0	0	0

¹ Detroit arrivals include 1,036 boats from Canadian ports only.

² Collaborators stationed at these ports.

³ Honolulu records available to Apr. 30, 1928.

⁴ Newport News records from Oct. 24, 1927.

⁵ Norfolk records from Sept. 22, 1927 (date port was opened).

TABLE 3.—*Ships inspected during fiscal year 1928—Continued*

Port	From foreign ports						From Hawaii						From Porto Rico					
	Direct			Via United States ports			Direct			Via			Direct			Via		
	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband
Seattle ¹	2,493	1,104	568	195	161	54	11	11	8	21	14	2	0	0	0	0	0	0
Tampa ²	380	380	42	289	289	1	0	0	0	0	0	0	9	9	2	4	4	0
Porto Rico.....	1,127	1,127	426	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0
Total.....	23,777	19,473	8,120	10,721	7,449	2,171	400	400	120	103	94	19	307	293	153	183	164	67

² Collaborators stationed at these ports.

⁴ Seattle arrivals include coal barges, fish boats, and tugs from Canadian ports only.

The foreign ship arrivals do not in all cases agree with customs figures. Foreign ships may put in for bunkers and be inspected by Federal Horticultural Board inspector but not entered by customs. On the other hand, boats entered at certain small outside ports are included in customs records but not in this report.

TABLE 4.—*Inspection of shipments of plants and plant products offered for entry, fiscal year 1928*

Port	Shipments inspected and entered under permit	Shipments refused entry
	Number	Number
Astoria.....	0	0
Baltimore.....	419	0
Boston.....	2,178	1
Charleston.....	160	0
Chicago.....	345	1
Detroit.....	148	21
Galveston.....	106	2
Gulftport ¹	0	0
Houston.....	54	0
Honolulu ^{1,2}	279	32
Jacksonville ¹	2	0
Key West ¹	925	5
Los Angeles ¹	25	2
Miami ¹	117	0
Mobile ¹	199	0
Newport News ¹	0	0
New Orleans.....	2,652	15
New York.....	16,886	55
Norfolk ³	162	0
Pascagoula ¹	0	0
Pensacola ¹	4	0
Philadelphia.....	1,102	11
Portland, Oreg.....	121	1
Porto Rico.....	593	2
Providence.....	84	2
San Diego ¹	61	6
San Francisco ¹	1,335	0
San Pedro ¹	358	20
Savannah ¹	136	0
Seattle.....	899	2
St. Louis.....	29	0
Tampa ¹	475	3
Total.....	29,854	181

¹ Collaborators are stationed at these ports.

² Honolulu records available only to Apr. 30, 1928.

³ Norfolk records from Sept. 22, 1927 (date port was opened).

CARGO INSPECTION

All cargoes of plants and plant products subject to quarantine restrictions, with the exception of special permit plant material imported under regulation 14 of quarantine 37, which was examined in Washington, D. C., or San Francisco, Calif., were inspected at the port of entry or port of first arrival. During the year a total of 30,035 shipments was inspected; 29,854 were permitted entry under permit and 181 refused entry.

In addition to the inspection referred to above, inspectors of the board supervised, at commercially operated plants, the treatment of commodities requiring disinfection as a condition of entry, as follows: Cotton, 275,478 bales (including 2,857 bales of linters), and 891 packages (including 9 packages of linters); cotton waste, 16,132 bales and 28 packages; bagging, 1,071 bales; broomcorn, 572 bales, and 362 brooms. They also supervised, at Federal and commercial plants, the disinfection of 283 samples of cotton, cotton waste, and linters which arrived by parcel post at approved ports other than Washington.

All shipments of European chestnuts found to be infested with living insects were given the hot-water treatment as a condition of entry. This treatment was also given to 24,643,420 narcissus bulbs entered under special permit.

In addition, considerable time was devoted to the supervision of the cleaning by importers of products contaminated with objectionable material, such as soil, and the inspection of miscellaneous cargoes, where examination

was necessary to establish the true status of the shipment.

Inspectors at the ports of New Orleans, Houston, and Galveston are frequently called upon to make inspections of ships' holds and storage space on the docks for the presence of insects injurious to flour. At New Orleans 196 ship and 200 dock inspections were made during the year; at Houston 14 ships' holds and at Galveston 88 ships' holds were inspected.

INSPECTION OF SPECIAL PERMIT AND DEPARTMENTAL IMPORTATIONS

With the exception of a few shipments which are inspected at San

Francisco, all plant material entered under special permit is examined at the inspection house in Washington. A tabular record of such material is given on pages 17-20. In addition, all departmental importations and distributions from Washington are inspected there, as well as shipments of domestic plants entering and leaving the District, etc. A summary of the inspection work performed at the inspection house for the year under review is given in Table 5.

TABLE 5.—Summary of plants and plant products offered for inspection in the District of Columbia, fiscal year 1928

Material inspected	Foreign	Domestic	Fumigated	Otherwise treated	Infested with insects	Infected with diseases
	Number	Number	Number	Number	Number	Number
Lots of seed (departmental).....	2,956	2,682	3,887	633	174	56
Number of plants, bulbs, roots, rhizomes, etc. (departmental).....	23,883	115,023	9,403	9,749	1,512	1,149
Shipments of plants under regulation 14, quarantine 37 (commercial).....	1,185	-----	129	65	147	317
Shipments of plants under regulations 3 and 15, quarantine 37 (commercial).....	798	-----	3,590	23	19	6
Containers of domestic plants, other than departmental (mail, express, and freight).....	-----	11,161	-----	-----	-----	-----
Shipments of plants for distribution by U. S. Botanic Garden.....	-----	4,521	-----	-----	-----	-----
Shipments of plants by private individuals.....	-----	260	-----	-----	-----	-----
Interceptions of plants and plant products referred to Washington.....	810	-----	351	192	51	9
Cotton samples referred to Washington.....	16,384	-----	16,384	-----	-----	-----

¹ Lots.

TABLE 6.—Inspection of foreign parcel post packages, fiscal year 1928

Port	Inspected	Refused entry (entire or part)	Diverted to Washington, D. C.
	Number	Number	Number
Astoria.....	2	0	0
Baltimore.....	32	14	17
Boston.....	1,597	124	1,277
Chicago.....	1,084	417	94
Detroit.....	2,666	232	181
Jacksonville ¹	86	32	6
Los Angeles ¹	4,290	257	166
Miami ¹	27	25	0
Mobile ¹	15	6	1
New York.....	2,966	405	1,203
New Orleans.....	21	10	11
Philadelphia.....	2,750	326	286
Portland, Oreg.....	45	7	16
Porto Rico.....	32	11	0
San Diego ¹	42	2	2
San Francisco ¹	1,528	209	42
St. Louis.....	133	30	45
Seattle.....	208	116	10
Total.....	17,524	2,223	3,357

¹ Collaborators are stationed at these ports.

The above figures do not include 66,294 packages of shamrocks, approximately 50,000 packages of which arrived at New York, 9,888 packages at Chicago, and 6,406 packages at Boston.

FOREIGN PARCEL-POST INSPECTION

This service is performed in cooperation with customs and post-office officials. All mail packages from foreign countries which upon examination or external evidence are found to contain plants or plant products are referred to an inspector of the board for examination. Such mail packages arriving at ports where there are no representatives of the board are dispatched to the nearest port at which inspectors are stationed. Table 6 indicates the number and disposition of foreign packages containing plants and plant products which were inspected during the year.

INSPECTION IN PORTO RICO AND HAWAII

The responsibility for inspecting foreign vessels and plants and plant products arriving at Porto Rican ports was assumed by representatives of the board on July 1, 1927. In this work, the representatives of the board have been materially aided by inspectors of the insular department of agriculture. In

addition to this work, the inspectors of this board stationed in Porto Rico are charged with the enforcement of quarantine 58, fruit and vegetable quarantine of Porto Rico, which governs the movement of these products from that island to the mainland. All fruits and vegetables moving to the mainland were inspected and certified, such inspection having been made in the fields, groves, and packing houses. During the year 5,303 shipments, representing 1,955,147 containers, of various fruits and vegetables were inspected and certified.

Provision was also made at the beginning of the fiscal year for the inspection in Porto Rico of parcel-post packages destined for points on the mainland, the object being to intercept, prior to shipment, packages which might contain fruits and vegetables infested with living injurious insects, including fruit flies. During the period August 1, 1927, to June 30, 1928, a total of 2,793 packages was inspected. Of this number, 243 were found to contain prohibited plants and plant products and were returned to the senders.

During the year an airplane service was established between Porto Rico, Cuba, Haiti, and the Dominican Republic. Baggage, etc., in the possession of passengers arriving on 77 airplanes were inspected in cooperation with customs officials, and 12 of the airplanes were found to carry contraband material.

The bulk of the quarantine work in Hawaii relates to the enforcement of quarantine 13 on account of the Mediterranean fruit fly and melon fly. Some work, however, is necessary in connection with the enforcement of quarantine 60, which prohibits the movement of plants bearing soil from Hawaii to the mainland. The inspection work under quarantine 13 consists of inspections of fruits and vegetables at packing houses, inspections of plantations to insure their freedom from infestation by the Mediterranean fruit fly, and the supervision of packing material used in shipments of fruits allowed entry into the mainland under regulation. A summary of these inspections is shown in Table 7.

TABLE 7.—*Fruits and vegetables inspected and certified for shipment from Hawaii to the mainland, fiscal year 1928*

Month	Bananas ¹	Pine-apples	Taro	Coconuts	Ginger root	Lily root	Cassava	Certificates issued
July.....	12, 332	771	215	30	24	172	0	138
August.....	16, 795	633	547	12	115	224	0	176
September.....	15, 540	1, 024	563	100	87	402	0	178
October.....	19, 727	1, 065	834	44	39	248	1	173
November.....	28, 111	1, 228	906	120	142	303	0	194
December.....	19, 883	1, 421	564	116	141	356	0	118
January.....	18, 431	955	209	182	147	315	0	118
February.....	16, 726	866	449	222	81	199	0	161
March.....	14, 306	699	286	137	289	352	0	184
April.....	11, 389	363	115	58	131	244	0	118
May.....	14, 817	1, 312	30	170	99	177	0	163
June.....	12, 627	891	16	109	11	215	1	172
Total.....	200, 684	11, 228	4, 734	1, 300	1, 306	3, 207	2	1, 893

¹ Bananas by bunches, remainder by containers.

To expedite the release of baggage arriving on the mainland from Hawaii, arrangements have been made to provide, upon request of passengers, inspection and sealing of such baggage in Hawaii prior to sailing. If upon arrival at the mainland port of entry the seal is found intact, no further inspection is required.

As in previous years, the inspection work in Hawaii was performed by representatives of the Bureau of Entomology in cooperation with the board.

INSPECTION OF PLANT INTRODUCTION AND PROPAGATING GARDENS

The practice of inspecting and certifying plants for distribution by the Bureau of Plant Industry from its field introduction and propagating gardens was continued as in the past. With the exception of the plants distributed from Mandan, N. Dak., and Chico, Calif., these inspections were made by the inspectors of the board. The inspections at Mandan and Chico were performed by State officials serv-

ing as collaborators of the board, effecting a considerable saving in the form of transportation. Table 8 indicates the number of plants inspected and certified for distribution.

TABLE 8.—Summary of plants, bud sticks, cuttings, tubers, and roots examined for distribution from plant introduction and propagating gardens, fiscal year 1928

Station	Plants	Bud sticks, cuttings, tubers, and roots
	Number	Number
Bell, Md.	22,584	281
Chapman Field, Fla.	1,983	592
Chico, Calif.	15,090	10,288
Mandan, N. Dak.	322,165	-----
Savannah, Ga.	10,332	175
Total	372,154	11,336

PESTS INTERCEPTED

During the fiscal year the inspectors and collaborators of the board collected on or in imported plants and plant products 579 recognized species and 515 insects which could be assigned to family or genera only. These interceptions included many pests known to be injurious to agriculture. The West Indian fruit fly was taken in grape from Peru and in mangoes from Cuba, Haiti, and Jamaica. The Mexican fruit worm was taken in guava, mamey, mango, orange, peach, pear, quince, and sapote from Mexico. The melon fly was found in cucumber and green beans from Hawaii; Mediterranean fruit fly in orange from Algeria, peach from Azores, avocado, coffee berry, and mango from Hawaii; locust pod, *Opuntia* sp., peach, tangerine, bitter orange, and, in the hold of a ship from Italy, loquat, mango, and *Opuntia* sp. from Madeira Islands, sour orange from Sicily, and grape and orange from Spain; the olive fruit fly in olive from Italy; and the cherry fruit fly in cherries from France. The nut fruit tortrix, *Laspeyresia splendana reaumurana*, was intercepted in chestnuts from France and Italy, and weevils, *Balaninus* spp., were found in chestnuts from China, France, Italy, Japan, Spain, and Switzerland, and in acorns from France and Turkey, filberts from Italy and Spain, and walnuts from Italy.

The pink bollworm infested cotton-seeds from Dominican Republic, Egypt, Syria, and India, and cotton bolls and raw cotton from Hawaii. *Chilo sim-*

plex was taken in rice straw from Japan and *Chilo* sp. in sugar cane from Mexico. The bean-pod borer was taken in Lima beans from Cuba and green beans from Haiti.

The West Indian sweet-potato weevil (*Euscepes batatae*) was found in sweet potatoes from Brazil, Cuba, and Porto Rico. The turnip gall weevil infested turnips from England, Belgium, Holland, Denmark, and France.

Avocado weevils, *Conotrachelus aguacatae* and *Heilipus* sp., were taken in avocados from Mexico and the Canal Zone, respectively.

The dagger moth, sorrel cutworm, white tree pierid, European tussock moth, browntail moth, and *Papilio podalirius* infested fruit stocks from France.

A total of 6,893 interceptions of insects and plant diseases was forwarded to Washington by inspectors and collaborators of the board during the fiscal year. The collaborators in California and Florida also made 2,269 interceptions of insects and 28 of diseases, and 285 insects and 195 diseases, respectively, which were identified by State authorities.

TABLE 9.—Total number of interceptions of insects and plant diseases forwarded to Washington for identification, fiscal year 1928

Port	Insects	Plant diseases
Astoria	57	40
Baltimore	198	81
Boston	525	113
Brownsville	29	0
Calexico	2	0
Charleston	155	115
Chicago	24	16
Del Rio	8	0
Detroit	125	28
Douglas	9	2
Eagle Pass	17	0
El Paso	79	10
Galveston	17	1
Hidalgo	29	1
Laredo	20	2
Mobile	70	8
New Orleans	315	34
New York	1,134	158
Nogales	30	12
Norfolk	17	3
Philadelphia	1,782	478
Portland, Oreg.	15	13
San Francisco	38	1
San Juan, P. R.	37	5
San Pedro	0	0
San Ysidro	9	0
Seattle	410	147
St. Louis	5	2
Miscellaneous	170	58
Total	5,326	1,333

1 Collaborators are stationed at these ports.

2 Port of Norfolk opened Sept. 22, 1927.

INTERCEPTIONS OF PROHIBITED PLANTS AND PLANT PRODUCTS

Sixteen thousand eight hundred and thirty-six interceptions of prohibited plants and plant products from 97 different foreign countries were made during the year; 11,886 of these inter-

ceptions were made in baggage, 1,979 in mail, 243 in cargo, 906 in ships' stores, 1,092 in quarters, and 729 at appraisers stores. These interceptions represent material which was actually seized and destroyed.

TABLE 10.—Number of interceptions of contraband plants and plant products, fiscal year 1928

Port	In baggage	In mail	In cargo	In stores	In quarters
Astoria.....	0	0	0	7	0
Baltimore.....	1	11	0	0	11
Boston.....	319	153	1	4	4
Charleston.....	4	0	0	4	4
Chicago.....	0	417	0	0	0
Detroit.....	86	267	20	0	0
Galveston.....	37	0	0	16	2
Gulfport ¹	0	0	0	0	0
Houston.....	53	0	4	5	2
Honolulu ^{1 2}	2,886	19	7	0	0
Jacksonville ¹	1	20	0	28	0
Key West ¹	2,623	0	0	0	0
Los Angeles ¹	0	90	2	0	0
Miami ¹	951	1	1	66	239
Mobile ¹	8	0	0	42	14
Newport News ¹	0	0	0	0	0
New Orleans.....	368	0	5	87	254
New York ³	2,471	482	147	0	28
Norfolk.....	0	0	0	0	0
Pascagoula ¹	0	0	0	0	0
Pensacola ¹	0	0	0	22	3
Philadelphia.....	32	402	14	79	201
Portland, Oreg.....	0	13	1	0	0
Porto Rico.....	269	0	1	36	21
Providence.....	387	0	3	0	0
San Diego ¹	14	0	0	110	19
San Francisco ¹	703	29	19	259	223
San Pedro ¹	71	0	1	110	33
Savannah ¹	0	0	0	0	0
Seattle.....	563	55	2	4	3
St. Louis.....	0	20	0	0	0
Tampa ¹	39	0	15	27	31
Total.....	11,886	1,979	243	906	1,092

¹ Collaborators are stationed at these ports.

² Honolulu records available to Apr. 30, 1928.

³ In addition 729 interceptions were made in appraisers stores.

RECORDS OF IMPORTS OF RESTRICTED PLANTS AND PLANT PRODUCTS

Under various foreign quarantines certain plants and plant products are restricted as to entry and made subject to inspection and, if necessary, disinfection for the purpose of excluding various plant diseases and insect pests. Among these restricted plants and plant products are nursery stock, plants and seeds for propagation, fruits and vegetables, grains from certain countries, broomcorn and cotton, cotton waste, cotton wrappings, and cottonseed products. The records of the importations of these articles are indicated in the following discussion and tables:

IMPORTATIONS OF NURSERY STOCK, PLANTS, AND SEEDS

The importations recorded in Tables 11, 12, 13, 14, and 15, are entered under regulation 3 of quarantine 37, under permits which are made continuing and unlimited as to the quantity that may be imported. The restrictions under this regulation are intended merely to afford opportunity to inspect, and if necessary, to safeguard the products as they are so entered. In the case of Table 11 the entries made in the preceding year also are listed for the purpose of comparison, and in Table 13 the bulb entries of the preceding eight years are brought together to show the fluctuation in the entry of different classes of bulbs.

TABLE 11.—*Importation of fruit, rose and nut stocks, cuttings, and scions under regulation 3, quarantine 37, year ended June 30, 1928*

[Figures indicate number of plants]

Kind of stocks, cuttings, and scions	Austria	Canada	Czecho-slovakia	England	France	Germany	Greece	Holland	Hungary	Ireland	Italy
Apple	30	207	174	525	4,086,800	25	---	2,915	21	---	214
Cherry	---	150	16	650	7,100,400	---	---	1,703	15	---	---
Fig	---	8	---	13	940	---	---	---	715	---	40
Grape	---	---	---	200	---	---	103	---	---	---	25,400
Medlar	---	---	---	---	---	---	---	---	---	---	---
Mulberry	---	---	---	---	---	---	---	---	---	---	---
Nut	---	---	---	---	23,300	---	---	---	---	---	25
Peach	---	---	---	---	---	---	---	1,415	---	---	35
Pear	---	6	24	100	1,507,500	---	---	600	---	---	50
Plum	---	---	40	12	1,025,200	---	---	602	34	---	19
Prune	---	---	46	---	---	---	---	---	---	---	---
Quince	---	---	---	30	540,900	---	---	---	---	---	---
Rose	---	6	---	2,941,450	1,655,300	---	---	5,767,089	---	115,500	---
Total	30	399	300	2,942,980	15,943,840	25	103	5,775,115	785	115,500	25,783

Kind of stocks, cuttings, and scions	New Zealand	Palestine	Poland	Rumania	Scotland	Sweden	Syria	Union of Soviet Republics	Yugo-slavia	Total	
										1927-28	1926-27
Apple	30	---	16	110	---	4	---	38	112	4,091,221	3,710,760
Apricot	---	---	---	---	---	---	---	---	---	---	10
Blackberry	---	---	---	---	---	---	---	---	2	---	---
Cherry	---	---	---	---	---	---	---	16	61	7,103,017	6,874,730
Fig	---	---	---	---	---	---	---	---	56	---	804
Grape	---	21	---	---	---	---	8	66	---	27,274	268,368
Medlar	---	---	---	---	---	---	---	---	---	200	---
Mulberry	---	---	---	---	---	---	---	---	---	25	---
Nectarine	---	---	---	---	---	---	---	---	---	---	42
Nut	---	---	---	---	---	---	---	---	---	24,750	31,953
Olive	---	---	---	---	---	---	---	---	---	---	35
Peach	---	---	---	---	---	---	---	---	---	50	53
Pear	---	---	16	---	---	4	---	13	18	1,508,981	1,468,981
Pineapple	---	---	---	---	---	---	---	---	---	---	50
Plum	---	---	10	---	---	---	---	16	20	1,028,953	1,511,996
Pomegranate	---	---	---	---	---	---	---	---	---	---	46
Prune	---	---	---	---	---	---	---	---	---	---	---
Quince	---	---	---	---	---	---	---	---	---	540,930	962,650
Rose	---	---	---	---	25,000	---	---	---	---	10,505,436	12,011,510
Total	30	21	42	110	25,000	8	8	149	213	24,830,441	26,842,052

TABLE 12.—*Importation of bulbs under regulation 3 of quarantine 37, year ended June 30, 1928*

[Figures indicate number of bulbs]

Bulbs	Africa	Bermuda	Canada	China	Den- mark	Eng- land	France	Germany	Holland	Ireland	Japan	Pales- tine	Scot- land	Swit- zerland	Total
Chionodoxa.....						1,224			437,851						439,075
Convallaria.....					62,000	5,010			1,268,420	100					24,738,880
Crocus.....					3,791	3,791		23,403,350	8,771,384	12					8,775,467
Franchis.....	272				1,124	1,124			134,718			8			135,842
Fritillaria.....					624	624		10	111,144						111,778
Galanthus.....					2,124	2,124			660,865						662,989
Hyacinth.....	11				46	535,794			21,592,037						22,127,888
Ixia.....	12					9,134			704,632						704,644
Lily.....	251	1,169,076	208	73,802	9,335	510,007		19,548	434,755		17,700,424		12	200	19,917,477
Muscari.....					1,377	1,377			1,148,885						1,150,220
Sella.....	25					1,429			1,340,077	200					1,341,685
Tulip.....						31,300		2,100	161,905,988			1			161,940,818
Total.....	571	1,169,076	208	73,802	62,000	27,218	1,077,101	23,425,008	198,510,756	312	17,700,424	15	12	200	242,046,763

TABLE 13.—*Summary of bulb importations, regulation 3, quarantine 37, for the years 1920-21 to 1927-28*

[Figures indicate number of bulbs]

Bulbs	1920-21	1921-22	1922-23	1923-24	1924-25	1925-26	1926-27	1927-28
Chionodoxa ¹				339,766	465,422	839,637	466,872	439,075
Convallaria.....				17,568,835	18,980,311	20,543,785	20,538,460	24,738,880
Crocus.....	3,606,746	14,951,170	19,603,092	10,815,920	10,624,670	10,898,968	9,969,070	8,775,467
Franchis.....	5,514,805	6,319,082	8,286,500	93,314	152,787	214,173	144,150	135,842
Fritillaria ¹				92,951	104,483	209,543	125,688	111,778
Galanthus ¹				797,381	895,003	1,128,335	844,544	662,989
Hyacinth.....	22,568,891	24,808,236	29,142,707	32,197,740	27,947,261	23,682,560	23,711,178	22,127,888
Ixia.....				335,158	371,983	545,278	520,404	704,644
Lily.....	22,490,533	8,219,460	9,145,630	612,329	11,207,559	16,031,090	16,228,762	19,917,477
Muscari ¹				9,690,426	906,259	1,404,573	983,339	1,150,220
Nardus.....				92,659,666	106,314,049	142,384,199		
Sella.....	77,956,195	77,270,548	77,193,281	904,762	1,742,514	2,012,750	1,553,313	1,341,685
Tulip.....	55,075,343	64,846,940	76,719,116	92,539,157	96,290,452	106,849,572	129,681,036	161,940,818
Unclassified.....	4,756,369	70,750	183,900				11,112	
Total.....	191,968,882	196,486,186	220,274,316	288,737,465	276,002,753	326,744,463	204,816,928	242,046,763

¹ Imported under special permit from June 1, 1919, to Jan. 1, 1923.

TABLE 14.—*Importation of tree seeds under regulation 3, quarantine 37, year ended June 30, 1928*
 [Figures indicate number of pounds]

Country of origin	Apple	Apri-cot	Bana-na	Black- berry	Cherry	Grape	Jujube	Nut and palm	Orna- mental and tree	Papaya	Peach	Pear	Per- sim- mon	Plum	Pome- gran- ate	Quince	Rose	Miscel- lane- ous	Total
Africa.....								36,075	37										37
Australia.....								101	27									1	36,103
Austria.....	710	10			2,438			89	14,552			65	1	631			21		19,029
Brazil.....								100	7										96
British Guiana.....																			100
Canada.....									3,075										3,075
Canary Islands.....																			3,075
Chile.....									415										415
China.....							1	193	7,249		100	145	46						7,734
Colombia.....								79	2										9
Cuba.....								749											1,750
Czechoslovakia.....									519										519
Denmark.....																			1,500
France.....	174,475				2,397			92	3,840	3			15	117	3	5		1	242,333
Germany.....	352			5	1,329			21	2,633				286	100			23		4,769
Guam.....								84	4										88
Holland.....								100	538										638
Italy.....								14	19										33
India.....								55	1,667										1,722
Jamaica.....								14											14
Japan.....					30	5		925	1,537			1,707	125				425		15,774
Java.....									14										14
Manchuria.....												50							50
Mexico.....								44	5,513										5,594
New South Wales.....			36					1,320										1	1,320
New Zealand.....								206	133										339
Norway.....																			200
Philippine Islands.....								82	200										83
Poland.....									1										136
Samatra.....									136										2
Sumatra.....									2										538
Trinidad.....								537	1										22
Union of Socialistic Soviet Republics.....																			47
Yugoslavia.....									47										
Total.....	175,537	10	36	5	6,694	5	1	40,808	53,832	3	100	63,638	187	848	3		469	3	342,184

In addition to the seed importations shown in the preceding table, 225 packets of seeds, each containing only a small quantity, were entered as follows: Banana, France 3, Germany 1; blackberry, Germany 1; cherry, Germany 1; fig, China 1, France 2, Mexico 1, New Hebrides 1; grape, France 2, Germany 1, Java 3; mango, Java 2; nut and palm, Canal Zone 1, France 10, Honduras 1, India 1, Mexico 1, New Hebrides 1, Straits Settlements 2, Sweden 1, Trinidad 1, ornamental and tree, Africa 11, Australia 6, Canada 2, Canal Zone 3, Canary Islands 2, China 2, Colombia 1, Cuba 24, Czechoslovakia 1, England 11, France 53, Germany 6, Guatemala 2, Holland 4, Honduras 1, India 6, Ireland 1, Jamaica 3, Japan 6, Java 4, Mexico 5, New Hebrides 1, New Zealand 3, Philippine Islands 2, Portugal 1, Straits Settlements 3, Switzerland 1, Tahiti 1, Union of Socialistic Soviet Republics 1; papaya, Mexico 1; pear, China 2; persimmon, Germany 1; plum, Germany 1; raspberry, New Hebrides 1; rose, France 1, Germany 1; miscellaneous, Africa 1, Chile 2, Cuba 1, England 1, France 2, Java 1, New Hebrides 1. The quantity of seeds contained in these packets being very small, their distribution has not been shown in Table 15.

TABLE 15.—Distribution by States of bulbs, nursery stock, and seeds imported under regulation 3 of quarantine 37, during year ended June 30, 1928

State	Bulbs	Stocks, cuttings, and scions				Seeds				
		Fruit	Nut	Rose	Total	Fruit	Nut and palm	Orna- mental and tree	Rose	Total
	Cases	Number	Number	Number	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Alabama	364	890			890	40		356	20	416
Arizona	38									3
Arkansas	126							966		19,479
California	7,200	124,033		41,000	165,033	744	17,769	207		409
Colorado	7,732	70,000		70,000	200	200		1,035	5	2,025
Connecticut	2,483	1,407,218		1,233,500	2,640,718	625	360			
Delaware	2,322	20,000			20,000					
District of Columbia	735							3,726		3,726
Florida	129						1,003	120		1,123
Georgia	792	12,500			12,500	1,881	570	8,438	18	10,907
Idaho	61									
Illinois	24,191	46,510		1,186,300	1,232,810	60	48	9,010	3	9,121
Indiana	1,410	493,000		1,851,200	1,344,200		3	6	1	10
Iowa	1,443	2,731,600	1,000	172,500	2,905,100	200	20	659		879
Kansas	438	930,500		51,000	1,001,500	11,627	12	1,107		12,746
Kentucky	386	12,000			12,000			18		18
Louisiana	275						33	22		55
Maine	314							11		11
Maryland	1,248	230,025		30,000	260,025			73		76
Massachusetts	5,265	6,089		89,800	95,889	3		380		400
Michigan	4,729	294,400		101,000	395,400		11	143	6	148
Minnesota	2,090	357		4,500	4,857	15	30	852		897
Mississippi	138									
Missouri	2,670	1,471,864		130,500	1,602,364	4,800	12	10		4,822
Montana	171									
Nebraska	449									
Nevada	4									
New Hampshire	176						4	82	2	93
New Jersey	9,058	10,070		497,000	507,070			176		181
New Mexico	32	100						843	50	4,078
New York	68,151	5,062,212	20,715	3,952,180	9,035,107	222,431	15,107	9,255	210	247,003
North Carolina	293	175,000		5,000	180,000	2		273		276
North Dakota	82	200			200	1		89	5	95
Ohio	6,947	641,800	1,000	1,717,350	2,360,150	35	207	789	11	1,042
Oklahoma	242	88,000			88,000	100				100

TABLE 15.—*Distribution by States of bulbs, nursery stock, and seeds imported under regulation 3 of quarantine 37, during year ended June 30, 1923—Continued*

State	Stocks, cuttings, and scions				Seeds					
	Bulbs	Fruit	Nut	Rose	Total	Fruit	Nut and palm	Orna-mental and tree	Rose	Total
Oregon.....	Cases	Number	Number	Number		Pounds	Pounds	Pounds	Pounds	Pounds
Pennsylvania.....	1,007	30			30	294		296		590
Rhode Island.....	18,417	140,242	2,000	200,806	343,048	1,428	2,130	13,867	123	17,548
South Carolina.....	1,466	18,013		57,000	75,013			167	15	182
South Dakota.....	255									2
Tennessee.....	72			6,000	6,000			20		20
Texas.....	1,087	180,000		15,000	195,000		50	11		61
Utah.....	517	143,210	35	29,000	172,245	31	63	331		425
Vermont.....	262	30,000			30,000			3		3
Virginia.....	329									
Washington.....	687	25,150			25,150			55		55
West Virginia.....	1,847					2,550		264		2,814
Wisconsin.....	368	400			400		2		4	4
Wyoming.....	2,542	42		64,000	64,042		2	164		166
Exported by permittee.....	26									
Total.....	410	25,000	24,750	600	25,000		168	4		172
	172,586	14,300,255	24,750	10,505,436	24,830,441	247,072	40,808	53,832	469	342,181

In addition, 225 packets and 3 pounds of miscellaneous seeds were thus distributed.

The record of entry under special permits issued under the provisions of regulation 14 of quarantine 37 for the purpose of keeping the country supplied with new varieties and necessary propagating stock and to meet other technical and educational needs is given in Table 16.

TABLE 16.—*Special-permit importations, 1928, with combined total for the period 1920-1928*

Class of plants	Fiscal year 1928				Total, 1920-1928			
	Permits issued		Permits imported		Permits issued		Permits imported	
	Num- ber	Quantity	Num- ber	Quantity	Num- ber	Quantity	Num- ber	Quantity
Gladiolus.....	207	3,989,648	181	1,598,697	1,329	49,890,724	1,080	28,045,756
Dahlia.....	70	4,215	55	2,881	546	44,301	447	29,829
Iris, rhizomatous.....	170	22,616	143	8,069	1,143	254,438	960	126,679
Iris, bulbous.....	167	6,821,640	155	6,349,134	1,081	40,273,827	856	27,422,056
Other bulbs, rhizomes, and roots.....	163	845,108	147	604,207	1,145	12,036,920	886	6,076,891
Peony.....	111	49,282	89	24,521	960	1,349,087	757	632,810
Rose.....	116	20,316	87	9,460	908	194,249	754	136,948
Orchid.....	175	30,005	159	22,110	1,064	175,222	923	128,647
Ornamental.....	200	154,106	149	98,368	1,230	3,073,859	963	1,982,249
Herbaceous.....	142	94,630	118	54,177	1,051	4,659,916	828	2,878,323
Fruit trees and small fruits.....	32	4,403	20	2,616	129	14,647	82	6,661
Narcissus.....	281	25,917,240	226	15,869,180	688	135,340,909	441	56,374,862
Total.....		37,953,209		24,643,420		247,308,099		123,841,711

During the year 1,602 such permits were issued authorizing the entry of 37,953,209 plants and bulbs; a total of 24,643,420 plants and bulbs was imported under 1,357 permits as compared with a total of 46,722,087 plants and bulbs imported during 1927. Narcissus importations decreased from 40,505,682 in 1927 to 15,869,180 in 1928, while bulbous-iris importations increased from 4,174,911 to 6,349,134 during the same period. A summary of special permits issued during the entire period of the quarantine to date is given in Table 17. The number of varieties considered has now reached a total of 42,114 (an increase of nearly 5,000 during the year), of which 40,152 have been approved for entry. Table 18 shows the distribution of these varieties among the various classes of plants, as well as a comparison of the 1928 importations with those of 1927 for each class.

The distribution of the imported special-permit material by States is shown in Table 19. In addition to the foregoing there were imported from

Canada under regulation 15, quarantine 37, 318,887 bulbs, plants, trees, or cuttings, as compared with 413,259 during the fiscal year 1927. The total for the fiscal year 1928 includes 4,030 plants, etc., brought in by passengers through border ports where plant-quarantine inspectors are stationed.

TABLE 17.—*Special-permit importations, yearly totals, 1920-1928*

Fiscal year	Permits issued		Permits imported	
	Num- ber	Quantity	Num- ber	Quantity
1920.....	311	10,752,844	171	3,484,195
1921.....	622	13,965,013	411	8,132,634
1922.....	750	9,573,199	518	3,344,026
1923.....	897	15,175,003	719	10,357,406
1924.....	1,107	15,381,621	862	12,561,306
1925.....	1,235	9,517,913	1,087	8,575,129
1926.....	1,445	80,982,954	1,200	6,021,508
1927.....	1,453	54,006,343	1,256	146,722,087
1928.....	1,602	37,953,209	1,357	24,643,420
Total.....	9,422	247,308,099	7,581	123,841,711

¹ Errors found in the 1927 field reports and totals reduced accordingly.

TABLE 18.—*Special-permit material: Number of different varieties of plants requested and approved for fiscal years 1920-1923, and comparison of importations for fiscal years 1927 and 1928*

Class of plants	Number of varieties of plants requested and approved, 1920-1923			Comparison of 1927 and 1928 importations	
	Re- quested	Ap- proved	Percent- age ap- proved	1927	1928
Gladiolus.....	1,632	1,497	91.73	848,761	1,598,697
Dahlia.....	2,738	2,604	95.11	5,735	2,881
Iris, rhizomatous.....	2,361	2,252	95.38	8,625	8,069
Iris, bulbous.....	485	484	99.79	4,174,911	6,349,134
Other bulbs, rhizomes, and roots.....	2,583	2,553	98.84	889,459	604,207
Peony.....	1,928	1,679	87.09	24,909	24,521
Rose.....	3,658	3,286	89.83	16,491	9,460
Orchids.....	8,600	8,580	99.77	11,397	22,110
Ornamental.....	10,848	10,115	93.24	157,806	98,368
Herbaceous.....	5,719	5,560	97.22	76,296	54,177
Fruit trees and small fruits.....	305	293	96.07	2,015	2,616
Narcissus.....	1,257	1,249	99.36	40,505,682	15,869,180
Total.....	42,114	40,152	95.34	146,722,087	24,643,420

¹ Errors found in the 1927 field reports and totals reduced accordingly.

TABLE 19.—*Distribution of special-permit material by States for fiscal years 1920-1923*

State	Gladiolus	Dahlia	Rhizomatous Iris	Bulbous Iris	Peony	Rose	Orchid	Orna- mental	Narcissus	Total
Alabama.....	14,988	0	0	30,980	0	174	0	198	0	46,340
Arizona.....	12	14	0	0	0	9	14	2,557	0	2,606
Arkansas.....	0	0	0	18,000	0	0	0	0	0	18,000
California.....	1,839,937	4,832	26,539	10,639,753	2,181	24,827	31,764	2,078,615	5,364,552	20,013,000
Colorado.....	18,109	0	0	33,490	130	0	0	5,787	0	59,145
Connecticut.....	1,14,614	1,006	1,293	22,745	113	31,508	6	151,407	1,2,123	224,815
Delaware.....	2,000	0	22	215	16	0	826	5,310	5	8,879
District of Columbia.....	2,512	140	93	215	0	320	74	318	1,672	2,628,827
Florida.....	47,829	0	0	1,267,317	0	21	28	277,999	2	6,852,021
Georgia.....	9,210	300	181	128,455	0	0	0	2,988	5,831	147,055
Idaho.....	0	0	0	2,000	0	0	0	0	0	2,791
Illinois.....	3,242,759	95	14,142	881,390	44,831	9,746	545	226,390	221,025	4,640,243
Indiana.....	2,384,752	186	2,676	502,541	4,584	2,249	171	30,128	640	2,927,927
Iowa.....	111,585	0	4	10,035	24,010	0	0	14,295	250	160,179
Kansas.....	0	99	2,082	32	2,813	0	0	475	68	5,569
Kentucky.....	0	408	0	51,200	0	0	415	0	0	52,023
Louisiana.....	116	0	0	21,750	0	0	978	425	363	26,132
Maine.....	2,500	0	37	0	262	0	0	902	0	1,551
Maryland.....	350	439	395	325,575	19,891	500	449	61,117	827,322	1,258,745
Massachusetts.....	23,057	1,224	3,337	487,710	6,360	2,289	21,831	1,436,429	6,810	4,402,979
Michigan.....	3,436,969	3,411	3,346	793,678	81,627	0	317	572,263	2,164,395	15,963,008
Minnesota.....	12,343,441	49	1,523	5	7,440	160	612	35,552	1,000	130,885
Mississippi.....	84,544	0	9	49,776	0	0	0	252	0	56,537
Missouri.....	6,500	0	0	0	991	0	0	19,569	1,226	310,942
Montana.....	3,173	183	550	281,211	0	0	4,039	100	0	100
Nebraska.....	0	0	0	0	14	0	0	351	0	1,773
Nevada.....	1,132	276	0	0	0	0	0	0	0	0
New Hampshire.....	0	0	0	11,523	0	0	2	1,254	0	52,848
New Jersey.....	40,049	7	13	1,080,669	39,136	31,774	23,429	2,549,415	461,119	4,316,201
New Mexico.....	115,716	4,927	10,016	5,000	0	0	0	0	0	5,000
New York.....	0	0	0	3,224,012	201,793	18,241	28,152	3,013,429	9,684,213	18,710,273
North Carolina.....	2,505,452	4,364	30,617	2,757,258	0	0	0	763,739	1,041,305	4,491,759
North Dakota.....	692,375	82	0	0	0	0	0	0	0	23,412
Ohio.....	23,404	0	0	0	7	1	0	0	28	1,443,513
Oklahoma.....	482,305	1,994	19,997	46,856	124,398	4,276	420	763,239	0	1,147,708
Oregon.....	510	0	0	14,000	0	0	0	198	0	1,708
Pennsylvania.....	52,187	1,392	1,408	530,558	2,651	1,295	0	54,822	1,002,170	1,646,483
Rhode Island.....	370,554	1,390	2,494	176,493	51,551	5,462	11,531	252,094	1,778,659	2,650,228
.....	946	1,067	1,557	255,965	5,209	429	157	46,128	203,050	514,508

¹ Some material transferred to other States during the year.² Errors found in the 1927 field reports and totals reduced accordingly.

TABLE 19.—*Distribution of special-permit material by States for fiscal years 1920-1928—Continued*

State	Gladiolus	Dahlia	Rhizoma- tous Iris	Bulbous Iris	Peony	Rose	Orchid	Orna- mental	Narcissus	Total
South Carolina.....	0	0	0	30,000	0	0	0	3	8,809,500	8,809,503
South Dakota.....	472	0	11	0	2,432	1,807	0	551	0	5,273
Tennessee.....	0	590	357	188,896	232	87	0	3,442	737,225	930,899
Texas.....	2,000	1	50	693,271	0	290	6	75,398	6,138,237	6,910,253
Utah.....	60	0	0	28,250	0	0	0	2,747	11,100	14,147
Vermont.....	11,157	0	36	8,010	2,359	0	0	2,443	0	24,007
Virginia.....	19,681	293	3	2,327,054	1,376	0	45	44,066	4,732,340	7,134,858
Washington.....	84,968	618	3,381	1,373,703	3,315	646	0	139,780	6,591,229	8,217,840
West Virginia.....	230	0	0	4,000	0	0	0	36	0	4,266
Wisconsin.....	55,596	266	500	107,950	2,868	520	1,014	48,911	269,250	486,875
Wyoming.....	0	0	0	0	0	0	0	0	0	0
Total.....	28,045,756	29,829	126,679	27,422,056	632,810	136,948	128,647	10,941,124	56,374,862	123,841,711

IMPORTATIONS OF COTTON, COTTON WRAPPINGS, AND COTTON PRODUCTS

Tables 20 to 23 indicate, respectively, the importations of cotton, cotton waste, bagging, cottonseed, seed cotton, and cottonseed products during the year. The actual number of bales of cotton, cotton waste, and bagging is indicated, but inasmuch as bales vary in size, they are referred to as running bales.

In addition to the commercial importations indicated the board supervised the entry of 899 packages of cotton samples, including 9 packages of linters, imported by freight or express, 42 cotton-waste samples imported by freight or express, and 16,667 samples of cotton and cotton waste and linters imported by parcel post.

TABLE 20.—*Importation of running bales of ginned cotton, by country of growth and port of entry, 1927-28*

Country	Albany	Boston	Buffalo	Calexico	Charleston	Detroit	El Paso	Fabens	Houston	Island Pond	Jacksonville	Malone	Newport
Algeria.....		259											
Anglo-Egyptian Soudan.....		144											
China.....		2,081											
Dutch East Indies.....		245											
Egypt.....		142,019											
India.....		13,512											
Mexico.....				46,989			323	1,322					
Nigeria.....		321											
Peru.....		1,603											
United States (continental).....	37	9,045	83		28	151			1	518	8	241	1,390
Total.....	37	169,229	83	46,989	28	151	323	1,322	1	518	8	241	1,390

Country	New York	Niagara Falls	Nyando	Philadelphia	Port Huron	Portland	Richford	Rouses Point	St. Albans	San Francisco	Seattle	Vanceboro	Total
Algeria.....	57												316
Anglo-Egyptian Soudan.....													144
Asia Minor.....	10												10
Brazil.....	633												633
British West Indies.....	959												959
China.....	4,187					1,933				36,305	19,662		64,168
Colombia.....	2,849												2,849
Cuba.....	15												15
Dominican Republic.....	162												162
Dutch East Indies.....	786												1,031
Ecuador.....	970												970
Egypt.....	12,140												154,159
Haiti.....	3,306												3,306
India.....	17,113					25				1,618	125		32,393
Japan.....						200							200
Mexico.....	3,954									2,193			54,781
Nigeria.....													321
Peru.....	69,281												70,884
Porto Rico.....	1,064												1,064
United States (continental).....	62	383	1	120	4		447	60	569	1,700		739	15,587
Virgin Islands (United States).....	26												26
Total.....	117,574	383	1	120	4	2,158	447	60	569	41,816	19,787	739	1403,978

¹ Includes 7,274 bales of linters.

TABLE 21.—*Importation of running bales of cotton waste, by country of origin and port of entry, 1927-28*

Country	Baltimore	Boston	Buffalo	Charleston	Detroit	El Paso	Galveston	Holab	Island Pond	New Orleans	Newport	New York
Austria.....												465
Belgium.....		120										2, 942
Brazil.....		90										
Canada.....		1, 407			49			38	277		846	60
Ceylon.....		25										
China.....												185
England.....	77	5, 272		2, 608								2, 144
France.....		1, 555		106			26			7		1, 379
Germany.....	811	2, 384								31		3, 018
Holland.....		950		295			186					2, 050
India.....		12										4, 772
Italy.....		369										215
Japan.....		1, 415										1, 205
Mexico.....						28						1, 623
Scotland.....												83
Spain.....												658
Switzerland.....		1, 086										408
United States (returned).....			3	4								
Total.....	888	14, 685	3	3, 013	49	28	212	38	277	38	846	21, 207

Country	Niagara Falls	Norfolk	Philadelphia	Port Huron	Portland	Richford	Rouses Point	St. Albans	San Francisco	Seattle	Total
Austria.....											465
Belgium.....			27								3, 089
Brazil.....											90
Canada.....	92			127	106	2	402				3, 406
Ceylon.....			446								471
China.....			25		25				252	323	810
Czechoslovakia.....			3								3
England.....	15	1, 784									11, 900
France.....		764									3, 837
Germany.....		1, 658							191		8, 093
Holland.....		1, 531									5, 012
India.....		3, 447									8, 231
Italy.....		420									1, 004
Japan.....		2, 879							1, 836	5, 820	12, 655
Mexico.....											1, 651
Scotland.....			31								114
Spain.....											658
Sweden.....			169								169
Switzerland.....			246						188		1, 928
United States (returned).....						5					12
Total.....	92	15	13, 430	127	25	106	7	402	1, 967	6, 143	63, 598

TABLE 22.—*Importation of running bales of bagging, by country of origin and port of entry, 1927-28*

Country	Baltimore	Boston	Buffalo	Charleston	Chicago	Detroit	Galveston	Houston	New Orleans	Newport
Austria				67					233	
Belgium	8,502	752		662			52		6,269	
Canada					322	3,460				115
Cuba									1,386	
England	2,685	1,528	48	3,919			493	1,966	3,889	
France	4,160	157		450					3,545	
Germany	1,152	244		1,068			1,658	75	4,897	
Holland	2,848	168		168				20	2,755	
India		4,437								
Italy	224								602	
Nicaragua									15	
Scotland	514	346		126						
Spain									1,649	
Wales	112									
Total	20,197	7,632	48	6,460	322	3,460	2,203	2,061	22,240	115

Country	New York	Norfolk	Philadelphia	Port Huron	Richford	San Francisco	Savannah	Seattle	Total
Algeria	711		414						1,125
Argentina	34								34
Australia	6								6
Austria	1,828	835					521		3,484
Belgium	9,023	4,208	783				947		31,198
Canada	5,119		58	3,472	49			485	13,080
China						761		448	1,209
Cuba	35								1,421
Denmark	916								916
Egypt	408								408
England	8,435	11,799	7,229			2,488			41,479
France	12,643	1,647	1,391			475			24,468
Germany	6,504	8,459	249			3,340			27,646
Greece	91		9						100
Holland	7,290	5,959	415				278		19,901
India	115		4						4,556
Ireland	288								288
Italy	7,365		104						8,295
Japan	185	200	201		1,636			12,711	14,933
Malta	86								86
New Zealand	10								10
Nicaragua									15
Norway	753								753
Russia	543								543
Scotland	2,686		187				137		3,996
Spain	2,624		5						4,278
Wales	139								251
Total	67,837	33,107	11,049	3,472	49	2,397	8,186	13,644	204,479

TABLE 23.—*Importation, in tons, of cottonseed, seed cotton, and cottonseed hulls, cake, and meal, 1927-28*

Port	Cotton-seed	Seed cotton	Cotton-seed hulls	Cotton-seed cake	Cotton-seed meal
Boston				42	261
Calexico	30		321		
Eagle Pass				307	
El Paso				210	361
New York					25
San Francisco					50
Tacoma					50
Yuma		40			
Total	130	140	1321	559	747

¹ Entry of cottonseed, seed cotton, and cottonseed hulls grown in the Imperial Valley, Lower California, Mexico, is allowed under permit.

IMPORTATIONS OF FRUITS AND
VEGETABLES

The two following tables indicate the fruits and vegetables imported

under permit and inspection during the fiscal year, Table 24 by countries of origin and Table 25 by ports of entry.

TABLE 24.—*Fruits and vegetables imported during year ended June 30, 1928, by countries of origin*

[Quarantine 56 unless otherwise designated]

Kind	Country and quantity	Total
Apple.....pounds..	Chile, 85; Germany, 83; Holland, 20; Japan, 80.....	268
Apricot.....do.....	Argentina, 588.....	588
Aralia cordata.....do.....	China, 1,300.....	1,300
Artichoke.....do.....	Mexico, 221.....	221
Asparagus.....do.....	Argentina, 12,756.....	12,756
Avocado.....do.....	Cuba, 2,169,281; Dominica, British West Indies, 7,400; Dominican Republic, 23,923; Jamaica, 13,470; Mexico (seeds removed), 104,049; Peru, 550; St. Lucia, British West Indies, 6,620.....	2,330,293
Banana.....bunches..	Brazil, 11; Colombia, 1,817,650; Costa Rica, 5,235,342; Cuba, 2,756,947; Dominican Republic, 330; Guadeloupe, French West Indies, 7,071; Guatemala, 6,968,134; Haiti, 110; Honduras, 19,985,088; British Honduras, 115,765; Jamaica, 12,959,228; Mexico, 5,734,880; Nicaragua, 3,063,489; Panama (including Canal Zone), 4,540,766; St. Lucia, British West Indies, 100.....	63,184,911
Bean (green):		
Lima.....pounds..	Cuba, 2,729,473; Mexico, 48,745.....	2,778,218
String.....do.....	Cuba, 25,875; Mexico, 888,076.....	913,951
Beet.....do.....	Bermuda, 552,149; Cuba, 200; Mexico, 311,732.....	864,081
Berry (Rubus).....do.....	Norway, 4,116.....	4,116
Cabbage.....do.....	Bermuda, 46; Channel Islands, 400; Cuba, 20,080; Holland, 40,000; Mexico, 34,234.....	94,760
Cacao bean pod.....do.....	Costa Rica, 1,810; Jamaica, 20; Trinidad, British West Indies, 140.....	1,970
Carrot.....do.....	Bermuda, 1,373,525; Mexico, 652,219.....	2,025,744
Cassava.....do.....	China, 300; Costa Rica, 60; Cuba, 161,056; Dominican Republic, 367.....	161,783
Cauliflower.....do.....	Bermuda, 7; Mexico, 2,760.....	2,767
Celery.....do.....	Bermuda, 2,665,264; Mexico, 2,171.....	2,667,435
Chayote.....do.....	Cuba, 31,305; Dominican Republic, 4,811; Jamaica, 50; Mexico, 3,648.....	39,814
Cherry:		
Fresh.....do.....	Argentina, 93,100; Chile, 7,200.....	100,300
Processed.....do.....	Chile, 80,942; Italy, 1,377,029; Rumania, 170,717; Turkey, 14,710; Yugoslavia, 172,859.....	1,816,257
Cipollino.....do.....	Italy, 2,563,254; Morocco, 1,221,330; Spain, 2,182.....	3,786,766
Citrus medica.....do.....	Greece, 668; Italy, 3,145; Palestine, 20,206.....	24,019
Clover top.....do.....	Mexico, 634.....	634
Crosnes.....do.....	Belgium, 4,917.....	4,917
Cucumber.....do.....	Bermuda, 515; Cuba, 1,030,083; Mexico, 216,511.....	1,247,109
Dasheen (includes colocasia, caladium, inhame, malanga, and taro), pounds.	Azores, 492,601; China, 589,287; Costa Rica, 180; Cuba, 150,126; Dominican Republic, 839,350; Japan, 341,976; Mexico, 3,583; St. Lucia, British West Indies, 2,970.....	2,420,073
Eggplant.....pounds..	Cuba, 6,216,434; Mexico, 795,929; Virgin Islands, 48,564.....	7,060,927
Endive.....do.....	Belgium, 2,390,967.....	2,390,967
Fennel.....do.....	Bermuda, 4,748.....	4,748
Garlic.....do.....	Azores, 198; Chile, 752,416; Cuba, 5,160; Egypt, 63,510; Germany, 55,179; Holland, 21,827; Hungary, 92,650; Italy, 1,154,596; Mexico, 550,436; Spain, 2,750; Switzerland, 33,318; China, 426,609; Cuba, 1,255; Dominican Republic, 1,015; Jamaica, 270; Japan, 1,112; West Africa (Gold Coast), 340.....	2,732,040
Grapefruit.....do.....	Cuba, 3,457,891; Dominican Republic, 8; Haiti, 88; Jamaica, 22,530.....	3,480,517
Grape:		
Fresh (not hothouse) do.	Argentina, 3,748,844; Chile, 381,300; Mexico, 1,515.....	4,131,659
Hothouse.....do.....	Belgium, 356,649.....	356,649
Processed.....do.....	Italy, 284,438.....	284,438
Waste.....do.....	Italy, 13,037.....	13,037
Horse-radish.....do.....	Germany, 690,013.....	690,013
Husk tomato.....do.....	Mexico, 58,884.....	58,884
Jicama.....do.....	Mexico, 23,041.....	23,041
Kale.....do.....	Bermuda, 675,923.....	675,923
Kohl-rabi.....do.....	Bermuda, 1,041; Mexico, 106.....	1,147
Kudzu.....do.....	China, 129,483.....	129,483
Leek.....do.....	Cuba, 515.....	515
Lemon.....crates..	Argentina, 20; Azores, 2; Cuba, 1; Italy, 1,220,589; Mexico, 31; Spain, 277.....	1,220,920
Lettuce.....pounds..	Bermuda, 41,091; Mexico, 70,034.....	111,125
Lily bulb (edible).....do.....	China, 27,063.....	27,063

TABLE 24.—*Fruits and vegetables imported during year ended June 30, 1928, by countries of origin—Continued*

[Quarantine 56 unless otherwise designated]

Kind	Country and quantity	Total
Lime (sour).....pounds..	Bermuda, 875; Costa Rica, 5,000; Cuba, 7,025; Dominica, British West Indies, 3,104,275; Dominican Republic, 38,623; Haiti, 214; British Honduras, 2,100; Jamaica, 179,530; Mexico, 1,371,386; Panama, 1,500; St. Lucia, British West Indies, 195,080; Trinidad, British West Indies, 8,292.	4,913,900
Melon.....do.....	Argentina, 1,325,011; Chile, 1,904,137; Italy, 8,663; Mexico, 4,524,960; Spain, 445,084.	8,207,855
Mint.....do.....	Bermuda, 3,160; Mexico, 461	3,621
Mustard.....do.....	Bermuda, 4,080; Mexico, 52,526	56,606
Nectarine.....do.....	Belgium, 935; Chile, 32,460	33,395
Nuts (in the shell):		
Acorn.....do.....	Greece, 2,141,804; Italy, 1,693,081; Turkey, 4,229,915	8,064,800
Chestnut.....do.....	France, 37,919; Italy, 10,988,341; Spain, 26,262	11,052,522
Okra.....do.....	Cuba, 1,344,676; Mexico, 4,469	1,349,145
Onion.....do.....	Argentina, 110,500; Australia, 137,821; Azores, 323; Bermuda, 135,335; Chile, 12,045,677; China, 170; Cuba, 75,463; Dominica, British West Indies, 3,300; Egypt, 22,793,494; France, 60,000; Holland, 182,710; Italy, 1,079,654; Japan, 155,000; Mexico, 369,610; Montserrat, British West Indies, 24,500; Morocco (French), 8,590; Peru, 5,000; Spain, 43,110,121; Sweden, 22; Virgin Islands, 4,200.	80,301,490
Orange:		
Under quarantine 56, pounds.	Argentina, 66; Cuba, 65,295; Dominican Republic, 512; Haiti, 205; Jamaica, 24,500.	90,578
Mandarin (quarantine 28), pounds.	Japan, 1,410,390	1,410,390
Pachyrhizus.....pounds.....	China, 41,700	41,700
Parsley.....do.....	Bermuda, 1,592,614; Mexico, 28,325	1,620,939
Pea.....do.....	Bermuda, 33; Cuba, 1,050; Jamaica, 1,025; Mexico, 14,440,607	14,442,715
Peach.....do.....	Argentina, 76,000; Belgium, 945; Chile, 26,050	102,995
Pear.....do.....	Argentina, 20,000; Chile, 31,870	51,870
Pepper.....do.....	Bahamas, 5,680; Cuba, 6,007,932; Dominican Republic, 580; Mexico, 10,601,724; Virgin Islands, 14,634.	16,630,550
Pigeon pea.....do.....	Dominican Republic, 93	93
Pigweed.....do.....	Mexico, 435	435
Pineapple.....crates.....	Azores, 17; Costa Rica, 18,605; Cuba, 1,051,991; Dominican Republic, 5; Ecuador, 3; Haiti, 3,725; Honduras, 597; Mexico, 626; St. Lucia, British West Indies, 2; Venezuela, 6.	1,075,577
Plantain.....bunches.....	Costa Rica, 200; Cuba, 359,954; Dominican Republic, 16,349; Haiti, 21; Honduras, 88,879; British Honduras, 29,498; Mexico, 5,536; Panama (including Canal Zone), 28,631.	529,068
Plums.....pounds.....	Argentina, 38,194	38,194
Potato:		
Under quarantine 56, pounds.	Bermuda, 6,462,549	6,462,549
Under potato regulations (Order of Dec. 22, 1913) pounds.	Cuba, 4,225,795; Mexico, 812,041	5,037,836
Prickly pear.....pounds.....	Mexico, 11,167	11,167
Pumpkin.....do.....	Cuba, 48,577; Dominican Republic, 14,131; Jamaica, 1,240; Mexico, 12,136.	76,084
Purslane.....do.....	Mexico, 1,580	1,580
Radish.....do.....	Mexico, 81,332	81,332
Roselle.....do.....	Mexico, 260	260
Sage.....do.....	Mexico, 160	160
Sea onion.....do.....	Denmark, 2,713; Italy, 73	2,786
Sorrel.....do.....	Bermuda, 1,570	1,570
Spinach.....do.....	Bermuda, 755; Mexico, 139,274	140,029
Squash.....do.....	Cuba, 317,162; Mexico, 184,091	501,253
Strawberry.....do.....	Mexico, 1,466	1,466
Swiss chard.....do.....	Mexico, 7,990	7,990
Tamarind bean pod.....dc.....	Antigua, British West Indies, 14,925; Barbados, British West Indies, 500; Dominican Republic, 56; Mexico, 618; St. Kitts, British West Indies, 11,636.	27,735
Tangerine.....do.....	Cuba, 29,155	29,155
Tomato.....do.....	Bahamas, 9,134,163; Cuba, 19,815,221; Mexico, 91,677,490; Virgin Islands, 29,100.	120,655,974
Turnip.....do.....	Bermuda, 48,354; Mexico, 317,442	365,796
Vaccinium (cranberry, etc.), pounds.	Newfoundland, 551,078; Norway, 3,575; Sweden, 2,487	557,140
Water chestnut.....pounds.....	China, 1,370,283; Japan, 400	1,370,683
Water cress.....do.....	Mexico, 3,715	3,715
Water-lily root.....do.....	China, 48,371; Cuba, 200; Japan, 900	49,471
Watermelon.....do.....	Chile, 11,395; Mexico, 1,264,226; Peru, 725	1,276,346

TABLE 25.—*Fruits and vegetables imported during year ended June 30, 1928, by ports of entry*

[Quarantine 56 unless otherwise designated]

Kind	Port and quantity	Total
Apple.....pounds..	New York, 188; Seattle, 80.....	268
Apricot.....do.....	New York, 588.....	588
Aralia cordata.....do.....	San Francisco, 1,300.....	1,300
Artichoke.....do.....	Laredo, 221.....	221
Asparagus.....do.....	New York, 12,756.....	12,756
Avocado.....do.....	Brownsville (seeds removed), 491; Eagle Pass (seeds removed), 4,979; El Paso (seeds removed), 20,478; Hidalgo (seeds removed), 20; Key West, 523,438; Laredo (seeds removed), 79,226; Miami, 57,000; New Orleans, 744,313; New York, 557,968; Nogales (seeds removed), 55; Tampa, 313,525.....	2,330,293
Banana.....bunches..	Baltimore, 3,133,051; Boston, 3,521,972; Charleston, 1,049,356; Corpus Christi, 4,961; Douglas, 30; Eagle Pass, 13,102; El Paso, 330,740; Galveston, 1,000,262; Houston, 7,151; Key West, 13,579; Laredo, 43,169; Los Angeles, 949,399; Miami, 239,116; Mobile, 3,182,801; New Orleans, 23,537,346; New York, 18,601,480; Nogales, 551,569; Pensacola, 34,885; Philadelphia, 5,034,258; San Francisco, 1,190,089; Tampa, 746,595.....	63,184,911
Bean (green):		
Lima.....pounds..	Laredo, 2,729; New York, 2,729,473; Nogales, 23,307; San Diego, 5,842; San Ysidro, 16,867.....	2,778,218
String.....do.....	Brownsville, 69,744; Calexico, 58; Douglas, 4,382; Eagle Pass, 2,450; El Paso, 135,792; Laredo, 453,979; Los Angeles, 1,804; New York, 25,575; Nogales, 70,028; San Diego, 14,630; San Ysidro, 135,211.....	913,951
Beet.....do.....	Calexico, 90; Douglas, 14,529; Eagle Pass, 645; El Paso, 284,321; New York, 552,349; Nogales, 12,147.....	864,081
Berry (Rubus).....do.....	New York, 4,116.....	4,116
Cabbage.....do.....	Boston, 10,000; Calexico, 1,824; Douglas, 11,857; Eagle Pass, 1,162; El Paso, 2,550; Laredo, 4,145; New York, 20,526; Nogales, 12,451; Norfolk, 10,000; Philadelphia, 20,000; San Ysidro, 245.....	94,760
Cacao bean pod.....do.....	New York, 1,970.....	1,970
Carrot.....do.....	Calexico, 894; Douglas, 26,177; Eagle Pass, 548; El Paso, 616,777; Laredo, 90; New York, 1,373,525; Nogales, 7,823.....	2,025,744
Cassava.....do.....	Chicago, 300; Key West, 20,781; New York, 129,157; Tampa, 11,545.....	161,783
Cauliflower.....do.....	Douglas, 246; Eagle Pass, 65; Laredo, 390; New York, 7; Nogales, 2,059.....	2,767
Celery.....do.....	Douglas, 1,953; Laredo, 40; New York, 2,665,264; Nogales, 178.....	2,667,435
Chayote.....do.....	Boston, 50; El Paso, 3,233; Key West, 1,395; Laredo, 385; New Orleans, 10,165; New York, 23,861; Nogales, 30; Tampa, 695.....	39,814
Cherry:		
Fresh.....do.....	New York, 100,300.....	100,300
Processed.....do.....	Boston, 5,513; New York, 1,768,548; Philadelphia, 42,196.....	1,816,257
Cipollino.....do.....	Boston, 147,228; New York, 3,639,538.....	3,786,766
Citrus medica.....do.....	Detroit, 3,600; New York, 20,419.....	24,019
Clover top.....do.....	Douglas, 615; Nogales, 19.....	634
Crosnes.....do.....	New York, 4,917.....	4,917
Cucumber.....do.....	Brownsville, 585; Calexico, 50; Douglas, 3,027; Eagle Pass, 965; El Paso, 635; Key West, 270; Laredo, 6,412; New Orleans, 3,060; New York, 1,026,118; Nogales, 204,837; Tampa, 1,150.....	1,247,109
Dasheen (includes colocasia, caladium, inhame, malanga, and taro), pounds.	Boston, 23,754; Calexico, 3,583; Chicago, 4,700; Detroit, 1,900; Key West, 34,875; Los Angeles, 35,902; New York, 995,017; Portland, 9,500; Providence, 492,601; San Francisco, 579,624; Seattle, 171,397; Tampa, 67,220.....	2,420,073
Eggplant.....pounds..	Douglas, 411; Key West, 29,835; Laredo, 50; Los Angeles, 18,750; New Orleans, 666,015; New York, 5,556,668; Nogales, 776,718; Tampa, 12,480.....	7,060,927
Endive.....do.....	New York, 2,390,967.....	2,390,967
Fennel.....do.....	New York, 4,748.....	4,748
Garlic.....do.....	Boston, 179,677; Calexico, 472; Douglas, 10,183; Eagle Pass, 1,791; El Paso, 20,302; Laredo, 428,319; New Orleans, 171,695; New York, 1,900,508; Nogales, 8,368; Philadelphia, 10,527; Providence, 198.....	2,732,040
Ginger (crude).....do.....	Boston, 9,770; Chicago, 2,200; Detroit, 500; Los Angeles, 9,200; New Orleans, 45; New York, 89,895; Portland, 900; San Francisco, 276,640; Seattle, 41,751.....	430,601
Grapefruit.....do.....	Boston, 30,520; Chicago, 1,455,603; New York, 1,244,234; St. Louis, 750,160.....	3,450,517
Grape:		
Fresh (not hothouse).....do.....	Eagle Pass, 774; El Paso, 60; Laredo, 670; New York, 4,130,144; Nogales, 11.....	4,131,659
Hothouse.....do.....	New York, 356,649.....	356,649
Processed.....do.....	New York, 284,438.....	284,438
Waste.....do.....	New York, 13,037.....	13,037
Horse-radish.....do.....	Baltimore, 3,000; New York, 657,485; Philadelphia, 29,528.....	690,013
Husk tomato.....do.....	Brownsville, 2,257; Eagle Pass, 1,200; El Paso, 52,879; Hidalgo, 2,548.....	58,884
Jicama.....do.....	El Paso, 23,041.....	23,041

TABLE 25.—Fruits and vegetables imported during year ended June 30, 1928, by ports of entry—Continued

Kind	Port and quantity	Total
Kale.....pounds	New York, 675,923.....	675,923
Kohi-rabi.....do	New York, 1,041; Douglas, 106.....	1,147
Kudzu.....do	Boston, 4,324; Detroit, 200; Los Angeles, 10,500; New York, 31,580; Portland, 2,600; San Francisco, 60,584; Seattle, 19,695.....	129,483
Leek.....do	New York, 515.....	515
Lemon.....crates	Boston, 7,976; Brownsville, 1; Detroit, 75; Eagle Pass, 1; El Paso, 25; New Orleans, 137,299; New York, 1,073,821; Philadelphia, 991; Port Huron, 729; Providence, 2.....	1,220,920
Lettuce.....pounds	Calexico, 40; Douglas, 21,012; Eagle Pass, 1,749; El Paso, 26,664; New York, 41,091; Nogales, 20,569.....	111,125
Lily bulb (edible).....do	Boston, 2,984; Chicago, 1,400; Detroit, 200; New York, 7,620; San Francisco, 9,368; Seattle, 5,491.....	27,063
Lime (sour).....do	Boston, 5,010; Brownsville, 7,879; Eagle Pass, 121,320; El Paso, 59,695; Laredo, 1,040,905; Los Angeles, 103,205; Mobile, 17,100; New Orleans, 93,876; New York, 3,440,679; Nogales, 13,276; San Francisco, 3,940; Tampa, 7,015.....	4,913,900
Melon.....do	Boston, 1,543; Calexico, 50,062; Douglas, 85; El Paso, 1,180; Laredo, 320; New York, 3,681,352; Nogales, 4,473,313.....	8,207,855
Mint.....do	Calexico, 88; Douglas, 84; El Paso, 289; New York, 3,160.....	3,621
Mustard.....do	Calexico, 8,538; Douglas, 11,026; Eagle Pass, 12; El Paso, 23,455; New York, 4,080; Nogales, 9,492; San Ysidro, 3.....	56,606
Nectarine.....do	New York, 33,395.....	33,395
Nuts (in the shell):		
Acorn.....do	New York, 8,064,800.....	8,064,800
Chestnut.....do	Boston, 705,329; Los Angeles, 55,000; New York, 10,289,853; Philadelphia, 2,340.....	11,052,522
Okra.....do	Key West, 26,340; New Orleans, 749,229; New York, 550,092; Nogales, 449; Tampa, 23,035.....	1,349,145
Onion.....do	Boston, 8,596,623; Brownsville, 1,205; Calexico, 1,319; Douglas, 42,156; Eagle Pass, 925; El Paso, 257,032; Key West, 3,620; Laredo, 31,380; New Orleans, 3,582; New York, 71,033,663; Nogales, 20,948; Philadelphia, 11,023; Providence, 323; San Francisco, 170; San Ysidro, 4,700; Seattle, 292,821.....	80,301,490
Orange:		
Under quarantine 56 do.....	Boston, 11,340; Chicago, 61,600; New York, 17,638.....	90,578
Mandarin (quarantine 28), pounds.....	Seattle, 1,410,390.....	1,410,390
Pachyrhizus.....pounds	San Francisco, 41,700.....	41,700
Parsley.....do	Douglas, 1,866; Eagle Pass, 164; El Paso, 26,118; New York, 1,592,614; Nogales, 177.....	1,620,939
Pea.....do	Calexico, 2,150; Douglas, 636; Eagle Pass, 100; El Paso, 2,685; Laredo, 844; Los Angeles, 4,941; New York, 2,108; Nogales, 14,234,104; San Diego, 40,179; San Ysidro, 154,968.....	14,442,715
Peach.....do	New York, 102,995.....	102,995
Pear.....do	New York, 51,870.....	51,870
Pepper.....do	Brownsville, 4,776; Calexico, 458; Del Rio, 10,551; Douglas, 22,574; Eagle Pass, 93,297; El Paso, 554,206; Hidalgo, 3,701; Key West, 55,702; Laredo, 176,968; Los Angeles, 6,132; Miami, 2,240; New Orleans, 541,020; New York, 5,426,314; Nogales, 9,729,031; San Francisco, 30; Tampa, 3,550.....	16,630,550
Pigeon pea.....do	New York, 93.....	93
Pigweed.....do	Douglas, 317; Nogales, 118.....	435
Pineapple.....crates	Boston, 100; Brownsville, 2; Eagle Pass, 3; El Paso, 318; Key West, 791,401; Laredo, 92; Los Angeles, 10; Miami, 184; New Orleans, 23,668; New York, 248,709; Nogales, 200; Providence, 17; San Francisco, 780; Tampa, 10,093.....	1,075,577
Plantain.....bunches	Boston, 2,418; Key West, 95,314; Miami, 26,375; Mobile, 3,404; New Orleans, 56,030; New York, 83,583; Nogales, 1; Philadelphia, 60,000; San Francisco, 100; Tampa, 201,843.....	529,068
Plum.....pounds	New York, 38,194.....	38,194
Potato:		
Under quarantine 56, pounds.....	New York, 6,462,549.....	6,462,549
Under potato regulations (order of Dec. 22, 1913), pounds.....	Douglas, 687,583; Key West, 659,570; New York, 3,566,225; Nogales, 124,458.....	5,037,836
Prickly pear.....pounds	Eagle Pass, 60; El Paso, 9,457; Laredo, 1,650.....	11,167
Pumpkin.....do	Brownsville, 222; Douglas, 2,516; Eagle Pass, 4,443; El Paso, 450; Key West, 26,724; Laredo, 4,505; New York, 28,261; Tampa, 8,963.....	76,084
Purslane.....do	Douglas, 31; Nogales, 1,549.....	1,580
Radish.....do	Calexico, 127; Douglas, 5,457; Eagle Pass, 238; El Paso, 68,000; Laredo, 50; Nogales, 6,286; San Ysidro, 1,174.....	81,332
Roselle.....do	Nogales, 260.....	260
Sage.....do	San Ysidro, 160.....	160
Sea onion.....do	New York, 2,786.....	2,786
Sorrel.....do	New York, 1,570.....	1,570
Spinach.....do	Calexico, 994; Douglas, 20,530; Eagle Pass, 157; El Paso, 93,674; New York, 755; Nogales, 23,919.....	140,029

TABLE 25.—*Fruits and vegetables imported during year ended June 30, 1928, by ports of entry—Continued*

Kind	Port and quantity	Total
Squash.....pounds..	Brownsville, 350; Calexico, 948; Douglas, 11,624; Eagle Pass, 30; El Paso, 72,626; Laredo, 975; Los Angeles, 5,880; New Orleans, 59,490; New York, 257,672; Nogales, 22,888; San Diego, 30,893; San Ysidro, 37,877.	501,253
Strawberry.....do.....	El Paso, 1,342; Laredo, 124.....	1,466
Swiss chard.....do.....	El Paso, 7,990.....	7,990
Tamarind bean pod.....do.....	El Paso, 510; Laredo, 88; New York, 27,117; Nogales, 20.....	27,735
Tangerine.....do.....	Chicago, 29,120; New York, 35.....	29,155
Tomato.....do.....	Brownsville, 35,810; Calexico, 46,921; Del Rio, 3,420; Douglas, 18,674; Eagle Pass, 104,392; El Paso, 778,922; Hidalgo, 850; Key West, 1,939,535; Laredo, 659,321; Los Angeles, 7,347,762; Miami, 2,276,680; New Orleans, 2,399,000; New York, 22,341,849; Nogales, 81,316,461; San Diego, 1,906; San Francisco, 1,315,831; San Ysidro, 47,220; Tampa, 21,420.....	120,655,974
Turnip.....do.....	Calexico, 1,345; Douglas, 12,560; Eagle Pass, 78; El Paso, 294,001; Laredo, 100; New York, 48,354; Nogales, 9,358.....	365,796
Vaccinium (cranberry, etc.), pounds.	Boston, 185,519; New York, 371,561; San Francisco, 60.....	557,140
Water chestnut.....pounds..	Boston, 50,645; Chicago, 41,500; Detroit, 6,000; Los Angeles, 45,000; New York, 441,820; Portland, 600; San Francisco, 525,680; Seattle, 259,438.....	1,370,683
Water cress.....do.....	Douglas, 3,036; Eagle Pass, 8; Nogales, 671.....	3,715
Water-lily root.....do.....	Boston, 1,900; Chicago, 3,000; New York, 2,592; Portland, 300; San Francisco, 25,530; Seattle, 16,149.....	49,471
Watermelon.....do.....	Calexico, 497,270; Douglas, 1,903; Eagle Pass, 2,130; El Paso, 6,140; New York, 12,120; Nogales, 756,778; San Ysidro, 5.....	1,276,346

In addition to the regulated imports for consumption entry recorded in the foregoing tables, the board supervised the entry under permit, for immediate exportation or immediate transportation and exportation in bond, of great quantities of plants and plant products. Among some of the principal items may be mentioned approximately 1,330,000 bulbs, 919,800 fruit and rose stocks, 2,022,000 convallaria pips, 75,400 plants, shrubs and trees, 1,396,000 pounds of citrus fruits, and 1,067,000 pounds of potatoes.

BROOMS, BROOMCORN, AND GRAIN

Tables 26 to 28 indicate, respectively, the importations under quarantine 41

of brooms and broomcorn, clean shelled corn, and other seeds. Importations of clean shelled corn from countries other than those listed in quarantine 24 total over 5,000,000 bushels and show the first yearly record of importations of such corn since it was placed under restriction on January 1, 1927. Practically the entire quantity was imported from Argentina.

In addition the board supervised the entry, under quarantine 24, of 57,823 bushels of clean shelled corn from Manchuria (29,253 bushels at San Francisco and 28,570 bushels at Seattle) and, under quarantine 55, of 6,805,435 pounds of seed or paddy rice from Mexico.

TABLE 26.—*Importation of brooms and broomcorn, by country of origin and port of entry, 1927-28*

Country	Boston		Brownsville	Detroit	Laredo
	Brooms	Broom-corn	Brooms	Broom-corn	Brooms
Italy.....	24	Bales 1 572		Bales	
Mexico.....			120		144
United States (returned).....				5	
Total.....	24	572	120	5	144

¹ 36 bales exported to Canada after sterilization.

TABLE 26.—*Importation of brooms and broomcorn, by country of origin and port of entry, 1927-28—Continued*

Country	New York		Port Huron	Seattle	Total	
	Brooms	Broom-corn	Broom-corn	Broom-corn	Brooms	Broom-corn
Germany.....	341	<i>Bales</i>	<i>Bales</i>	<i>Bales</i>	341	<i>Bales</i>
Italy.....	² 7,000				7,024	572
Mexico.....					264	
Rumania.....	24,104				24,104	
United States (returned).....		5	8	7		25
Total.....	31,445	5	8	7	31,733	597

² 1,000 brooms transshipped to Colombia.TABLE 27.—*Importation of clean shelled corn under quarantine 41, by port of entry and country of growth, 1927-28*

Port	Argentina	Bahama Islands	Canada		Haiti	United States (returned)		Total	
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Pkgs.</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Pkgs.</i>	<i>Bushels</i>	<i>Pkgs.</i>
Baltimore.....	22,048							22,048	
Bellingham.....	169,733							169,733	
Boston.....	1,957							1,957	
Detroit.....				1		481	10	481	11
Los Angeles.....	29,839							29,839	
Miami.....		24						24	
New Orleans.....	534,449							534,449	
New York.....	1,838,369				2			1,838,371	
Nyando.....			¼						¼
Philadelphia.....	254,137							254,137	
Portland.....	239,632							239,632	
San Francisco.....	727,680							727,680	
Seattle.....	742,165							742,165	
Tacoma.....	557,280							557,280	
Total.....	5,117,289	24	¼	1	2	481	10	5,117,796¼	11

TABLE 28.—*Importation of seeds, other than corn, under quarantine 41, by country of growth and port of entry*

Kind	New York				Seattle	Total
	France	Italy	Japan	Union of South Africa	Manchuria	
Broomcorn seed.....	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Job's tears.....	300	180				180
Pearl millet seed.....			92,460			300
Grain sorghum seed.....				105	400,000	92,460
Total.....	300	180	¹ 92,460	105	400,000	493,045

¹ Exported to Canada.

DOMESTIC PLANT QUARANTINES

During the year the board has enforced, either directly or in cooperation with the Bureau of Entomology and the Bureau of Plant Industry, 19 domestic plant quarantines concern-

ing, on the one hand, interstate movement and, on the other, movement between Porto Rico and Hawaii and the mainland. The Hawaiian and Porto Rican quarantines are in a sense analogous to the foreign quarantines and entail like methods of enforcement,

and for administrative purposes are considered elsewhere in connection with the discussion of the enforcement of foreign plant quarantines.

The important domestic plant quarantines on account of the white pine blister rust and the black stem rust of small grains, are enforced in cooperation with this board by the Bureau of Plant Industry, and those on account of the Mediterranean fruit fly and melon fly in Hawaii and on the mainland and the quarantines on account of the Japanese beetle, the European corn borer, and the gipsy and brown-tail moths, are enforced in cooperation with this board by the Bureau of Entomology. The detailed discussion of the results of these quarantines, cooperatively enforced by the bureaus of this department, is eliminated from this report inasmuch as these subjects will be considered in the reports of the bureaus concerned. As already indicated, with the beginning of the current fiscal year all of these quarantines will fall under the new plant quarantine and control administration. The following quarantine discussion deals, therefore, for the fiscal year 1928, only with those quarantines all activities of which are enforced by the Federal Horticultural Board. These include the quarantines on account of the pink bollworm of cotton, the *Thurberia* weevil, and the date scale, together with the Mexican fruit worm, the enforcement of which latter, due to financial conditions, was transferred from September 16 to the end of the fiscal year to the Bureau of Entomology.

STATUS OF PINK-BOLLWORM CONTROL

NEW OUTBREAK IN WEST TEXAS

A very serious development in the pink-bollworm situation was the determination, during the first three months of 1928, of the presence of this cotton pest in seven new counties of western Texas, viz., Ector, Midland, Martin, Andrews, Glasscock, Howard, and Dawson. Nearly 400,000 acres of cotton are grown in these counties, and this, together with the fact that the new area is on the edge of the main Cotton Belt and that cotton plantings are more or less continuous eastward to the Atlantic seaboard, gives this infestation a very much greater importance and makes it a greater menace than were the older and isolated infestations in western Texas, New Mexico, and Arizona.

Fortunately, this infestation was discovered at the very beginning stage, and the actual infestation determined

was at widely separated points and very light. The initial infestation was found at Odessa, in Ector County, December 31, 1927. The total points of infestation for all the counties concerned, as later determined by surveys conducted during January, February, and March, involved only 24 cotton fields. In addition to those named, the survey covered a wide fringe of counties in which nothing was found surrounding those determined as infested.

To develop this situation as rapidly as possible as a basis for the application of control measures, the inspections at the outset were limited to field examinations of the dead cotton stalks with whatever bolls remained attached. All the worms found in such bolls were dead, evidently having been killed during the severe cold period of about the end of December. The very natural but probably erroneous interpretation of such finding was that all the insects in the area had been thus killed. This interpretation, however, overlooks the fact that many worms remain in the seed and are carried to farmers' bins, or to gins, and oil mills, where they may be protected from the severity of the cold, and the further fact that a percentage enter the soil about the base of the plants to a depth of 2 or 3 inches and, forming their slight cocoon there, are fairly well protected. On the other hand, with the infestation as light as it was in the counties concerned, it is very difficult to find the worms in soil or in connection with seed, and no such findings were made.

After the extent of this new infestation had been disclosed, and to meet the emergency, the department, with the approval of the President, recommended that the item of \$287,800 assigned for pink-bollworm work in the agricultural appropriation bill for the fiscal year ended June 30, 1928, be increased by \$400,000, making a total of \$687,800, part of which to be made immediately available. Early in March House Joint Resolution 223 was passed as a separate measure, making \$200,000 immediately available until June 30, 1929. At the same time the item in the regular appropriation bill for 1929 was reduced to \$487,800, and the bill passed carrying that amount.

The immediate control plans carried out as to this area, in addition to bringing it under State and Federal quarantine restrictions, included (1) tracing and intercepting shipments out of the area likely to spread infestation; (2) sterilizing all cottonseed remaining in the area; (3) thoroughly cleaning gins, mills, and other concentration

centers so as to destroy material likely to carry over infestation into the next crop year; and (4) increased precautions to prevent the influx of cottonseed from the older infested areas to the west. The failure to find living larvæ in standing cotton seemed to render unnecessary the cleaning of the fields of dead stalks.

In the tracing work it was deemed desirable, on account of the possibility that this infestation might have started earlier than 1927, to follow up all movement of cotton and seed and farm equipment for the crop years 1925 and 1926 as well as for 1927. In fact, certain slight and not fully identified indications of possible presence of the pest at Odessa were noted in connection with the crop of 1925. Fortunately, the very slight foothold of the pest in the new area necessarily minimized the risk from any distribution of seed and especially of lint, and this would be particularly true for the years 1925 or 1926, when it was not possible definitely to determine any infestation. The tracing work involved the movement of 2,843 cars of cottonseed for crushing purposes, 141 small shipments of cottonseed likely to be used for planting purposes, 955 shipments of household goods likely to contain cottonseed, 286,543 bales of cotton lint, and 232,022 bales of cotton linters.

The 1927 movement of the articles indicated out of the area was given first attention as representing the major risk. As a result of this work, all shipments of cottonseed, except four shipments, part of which had already been planted, were intercepted and disposed of by burning, crushing, or otherwise. As a precautionary measure, the fields in which these four shipments of seed were planted will be given thoroughgoing inspections in connection with the crop of 1928. Tracing records of the movement of household goods showed that approximately 4,500 pounds of cottonseed were shipped out with such movement. All this seed was intercepted and destroyed. Over 90 per cent of the 1927 seed crop which moved for crushing was found to have gone to seven cottonseed oil mills close to the involved area, and these mills were thoroughly cleaned of all material likely to carry infestation. The balance went to scattered points which will be kept under observation this year (1928).

The movement of suspected material for the years 1925 and 1926 was also traced, and the areas to which such shipments were made will be scouted this season.

One of the most important of the control measures carried out with respect to this new area was the disinfection, in a manner to destroy any insect life present but not to injure it for planting purposes, of all cottonseed remaining on farms, at gins, or other places within the area. This work was carried out with the active cooperation of the authorities of the State of Texas, and involved the sterilization and treatment of some 310,416 bushels of seed (approximately 10,000,000 pounds).

These control and eradication efforts in connection with the crop of 1927 were intended to be merely preliminary to a radical effort to eradicate the pest by the enforcement of noncotton zones over the area beginning with 1928. It will be recalled that the very successful work of eradication in eastern Texas and in Louisiana, involving total areas possibly greater, though not in actual cotton acreage, than the present western area, was successfully accomplished by the establishment and enforcement of such noncotton zones over varying periods—one to three years. It will be recalled also that, in connection with such noncotton zones, a plan was ultimately devised for repayment of farmers for losses which they sustained as a result of their being prevented from growing cotton. This plan was voiced in the joint resolution of Congress of 1921, and provided for State payment of the growers' losses with Federal reimbursement to the State of not to exceed one-third of the amount so expended, and with a limitation of \$5 per acre—the loss to be based on the difference of the return to the farmer from corn or other cultivated crop as compared with cotton. In connection with the new outbreak, in western Texas, however, a situation developed which made it impossible to work on this older plan. The State of Texas was without funds to participate in meeting such costs, and no provision therefor could be made until the next meeting of the legislature.

In view of the emergency and the necessity for immediate action, the following joint resolution was passed by Congress and approved by the President May 21, 1928:

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That when any State shall have enacted legislation and taken measures, including the establishment and enforcement of noncotton zones, adequate, in the opinion of the Secretary of Agriculture, to eradicate the pink bollworm in any area thereof actually infested, or threatened, by such pest, the said Secretary, under regulations to be prescribed by him, is authorized to pay, out of \$5,000,000 hereby authorized to be appropriated, out of any money in the Treasury not otherwise appropriated, to be expended in cooperation with the proper authori-

ties of the State concerned in compensating any farmer for his actual and necessary loss due to the enforced nonproduction of cotton within said zones: *Provided*, That no part of the funds herein authorized to be appropriated shall be available for compensation in connection with the establishment of a noncotton zone in any county unless and until the live pink bollworm is found within such county or within a radius of five miles thereof: *Provided further*, That such loss as to noncotton zones established by the State of Texas shall be determined as provided for in existing statutes of that State, and similarly by similar statutes which may later be provided by other States concerned, and that in estimating such loss due account shall be taken of the value of other crops which may be produced on said land, so that the loss shall not exceed the difference in return to the farmer from cotton over such other crops: *Provided further*, That such determination of actual and necessary loss shall be subject to the review and approval of the Secretary of Agriculture: *And provided further*, That no reimbursement shall be made with respect to any farmer who has not complied in good faith with all of the quarantine and control regulations prescribed by said Secretary of Agriculture and such State relative to the pink bollworm: *And provided further*, That the appropriation herein authorized shall be available only for compensation for the crop of 1928 unless the State in which any noncotton zone is established shall thereafter appropriate and pay a sum in each year equal to the amount expended in such State by the United States under this authorization.

The first proviso of the joint resolution was added in executive session by the committee without consultation with the department and provides that the funds shall not be available "for compensation in connection with the establishment of a noncotton zone in any county unless and until the live pink bollworm is found within such county or within a radius of 5 miles thereof." This proviso unfortunately also has the effect, possibly not intended by its proposer, of preventing the establishment of any noncotton zone for the crop year of 1928 in any of the counties in which the pink bollworm was first found in 1927. This results from the condition already indicated, namely, that the scarcity of the pink bollworm in this area makes it practically impossible to find any insects at this time in relation to the crop of 1927 and therefore postpones the establishment of any noncotton zone until infestation, if it occurs, has been redetermined in connection with the crop of 1928 or later crops.

In pursuance of this resolution a supplemental estimate for an appropriation of \$5,000,000 for this work was, with the approval of the President, submitted to Congress on May 21, 1928, and was incorporated by the Senate committee in its amendments to the second deficiency bill. The language for this appropriation item carried the following proviso which agreed in substance with the similar proviso in the joint resolution:

Provided, That the appropriation herein made shall be available only for compensation for the crop of 1928, unless the State in which any noncotton

zone is established shall thereafter appropriate and pay a sum in each year equal to the amount expended in such State by the United States under this authorization.

On May 23, 1928, the amendment offered by the Senate committee, which provided for the appropriation of \$5,000,000 and included the proviso as quoted above, was approved by the Senate. (See Congressional Record, p. 9932.) The following day, without specific reference either to this item, the Department of Agriculture, cotton, or the pink bollworm, certain verbal changes, introduced as "relating to an item which was under consideration yesterday," were proposed on the floor of the Senate and agreed to. In point of fact, these changes applied to this proviso and destroyed the purpose of the joint resolution so far as it applied to the crop of 1928. The amended proviso reads as follows:

Provided, That the appropriation herein made shall be available only for compensation for the crop of 1928, and then only in such State in which any noncotton zone is established as shall appropriate and pay a sum equal to the amount expended in such State by the United States under this authorization.

The clear purpose of the proviso as submitted to, and as originally approved by, the Senate was, by provision for full Federal compensation for 1928, to meet the situation fully detailed in the preamble to the joint resolution, namely, the inability of Texas, the principal State concerned, under existing conditions, to make any payments on account of noncotton zones for the crop of 1928. The new wording defeats this purpose and, in addition, limits the availability of the appropriation to the single year 1928.

No apparent notice was taken of these changes, either in the Senate or the House, by the proponents of the pink bollworm item, and the department had no means of identifying the obscure verbal changes with the appropriation until after Congress adjourned and distribution was made of the printed copies of the second deficiency act for the fiscal year 1928.

Prior to the passage of the joint resolution referred to above, one county in Texas, namely, Brewster, in the Big Bend area, where the pink bollworm is so abundant that living specimens can be found at any time of the year, had been declared a noncotton zone by that State. This county, which is the only one in which a noncotton zone has been declared, involves production of only some 500 acres, and the Federal cost in the enforcement of a noncotton zone in this area would be comparatively small.

It would seem to be most unfortunate that a noncotton zone could not have been established to include the seven counties in the western extension area in connection with the crop of 1928. The eradication effort would have then had the advantage of being undertaken at the very incipency of the infestation and would have been further supported by the apparently very large winter kill of larvæ in the field already referred to and, incidentally, by the intensive clean-up and disinfection of seed on farm premises, at gins, and oil mills. A more favorable period for eradication work will not return, but it is possible that with the existing quarantine controls, spread can be prevented, and if infestation develops later this year (1928) a noncotton zone can be declared effective as to the crop of 1929. At the date at which this report is submitted it is not possible to give any information as to the outlook of infestation of the crop of this year. No infestation has yet been determined, and similarly no findings have been possible prior to September or October, in other years in areas as scantily infested as was the western extension group of counties in 1927.

It requires no argument to indicate the desirability of going forward with the thoroughgoing effort of eradication, especially in view of the successes which have been had with this method in former years. Unless eradication is effected, the pink bollworm is bound to spread eastward through the continuous cotton cultivation of Texas, and the hope of elimination of this pest from the cotton crop of North America will then be gone. An initial \$5,000,000 appropriation for eradication may seem large, but it is very trivial in comparison with the annual losses which may very possibly result from this pest should it gain distribution similar to that of the boll weevil—losses which might prove to be equal to if not greater than those occasioned by the weevil.

The source of this new infestation in western Texas has not been definitely determined. The early theory, which now seems not to have adequate proof, was that it had perhaps resulted from illegal transportation of planting seed from infested areas in the upper Rio Grande. It also was appreciated that, in part at least, it may have been occasioned by the uncontrolled movement of Mexican labor with picking sacks and other equipment contaminated with seed from Mexico. The effort to control this possibility of spread by road

movement is described in another section of this report. There is a possibility also that the pink-bollworm moths may have spread by flight, with the aid of strong winds, from the intensive infestation in the Big Bend area or the near-by very slightly infested Pecos areas.

Hitherto the prevention of such spread has evidently seen the wide natural barrier zone of semidesert and pasturage which has existed between the western extension of continuous cotton cultivation in Texas and the cotton plantings more or less infested with the pink bollworm in the Pecos and Rio Grande Valleys. The risk from the rather rapid narrowing of this zone by the continued westward movement of cotton cultivation has been fully recognized by State and Federal authorities, has been discussed in these annual reports, and has been the basis of annual inspections of such western extension of cotton. Such inspections resulted in the finding in 1925 of a slight indication of possible pink-bollworm infestation at Odessa, Tex., near the extreme advance of cotton, but no larvæ were found in the injured bolls to serve for accurate identification. The suspicion which was thus placed on a portion of this area led to the thorough inspection in 1927 which resulted in the disclosure of infestation in the crop of that year.

The Bureau of Entomology, in cooperation with the Federal Horticultural Board, had already undertaken investigations to determine the possibility of wind spread of the pest, and these investigations will be very much enlarged during the season of 1928. If the infestation in this western extension is due to wind spread, it is clear that the system of control should involve a radical effort to free from this pest a considerable part, if not all, of the infested areas in the Pecos and Rio Grande Valleys; in other words, the rather ambitious plan of eradicating this pest from the United States should be undertaken. This will necessarily involve cooperation with Mexico, but the conditions are such as to make the possibility of securing such cooperation much more promising now than in former years.

SITUATION AS TO OLDER AREAS OF INFESTATION

In the areas in central and eastern Texas and in Louisiana in which the pink bollworm seems to have been eradicated and over which it has not reappeared for a considerable series of

years, a thoroughgoing scouting effort was made in connection with the crop of 1927 with the object, if nothing was found, to discontinue annual scouting in these areas in order better to meet the increasing demands of the western areas. No signs of the pink bollworm were found as the result of this intensive effort.

In the western areas of more or less continuing infestation in the upper Rio Grande and Pecos Valleys in western Texas, and in New Mexico, and in the more recently determined infestation in southeastern Arizona and southwestern New Mexico, pink bollworms were found, for the most part in small numbers and spottedly, in connection with the crop of 1927. Except in the Big Bend area, the abundance of the pink bollworm in these western areas of infestation varies considerably from year to year, evidently largely because of climatic control. A condition of continuing and increasing infestation has, however, developed in the Big Bend district of the Rio Grande, and in important areas boll infestation, at the end of the season, has reached 100 per cent. As elsewhere noted, a noncotton zone is being enforced by Texas as to a portion of this area (Brewster County), beginning with 1928.

The only important change in the situation in these western areas was the finding of the pink bollworm in an isolated field in the Santa Cruz Valley of Arizona, a point farther west than this pest had hitherto reached. This advanced point is significant because of its indication of the risk of the pest's spreading to the important Salt River Valley plantings to the north. In connection with the discovery of this infestation in the Santa Cruz Valley, it is interesting and important to future scouting operations to note that it resulted from an examination of trash at the gin in the Postvale area, some 25 miles from the field to which the infestation was later traced. Investigation showed that the cotton from which this gin trash originated came from a field south of Tucson, and the subsequent scouting of this field revealed the presence there of the pink bollworm. Such examination of gin trash is recognized as a valuable adjunct to field scouting and aided later in the season in determining the presence of pink bollworm at half a dozen other areas in the general western region of the infestation. Incidentally thorough scouting throughout the Santa Cruz Valley

failed to show any other infested fields. Inasmuch as the Santa Cruz Valley was already under regulation on account of the *Thurberia* weevil, measures which would prevent spread of the pink bollworm were already in operation.

The effort to eradicate the pink bollworm in the infested areas in southeastern Arizona and southwestern New Mexico began in 1926 and was discussed in my report for 1927. An item of \$35,000 to continue this work was included in the second deficiency bill of the fiscal year 1927, which failed to pass. The need, however, was so urgent that other important work was discontinued and an actual clean-up of the infested fields (crop of 1926) was carried out early in 1927.

For the purpose of following up this eradication effort in connection with the crop of 1927, an urgent deficiency item of \$90,000 was approved and included in the first deficiency bill for 1928. These funds became available in December, 1927, and the areas determined to be infested by the pink bollworm in southeastern Arizona and southwestern New Mexico were again very thoroughly cleaned. This involved a total of 12,121 acres, some 300 of which were cleaned by the State of Arizona. There was also a thorough clean-up of cottonseed and trash on farm premises, at gins, in gin yards, at loading stations, etc. The eradication value of the work of these two years can not be determined until the crop of 1928 has been fully scouted.

FIELD SCOUTING WORK

Field scouting for the pink bollworm each year is a necessary continuing feature of control. The intensive scouting work of this year in the old areas, carried on with the idea of eliminating these areas from annual scoutings, has already been discussed. Nevertheless, the necessity will remain, because of the possibility of reinvasion from Mexico, of taking an accounting of these areas from time to time and of any other areas under suspicion, with the object of locating any new infestations at the earliest possible moment. Table 29 gives, in connection with the report of scouting by man-days for the crop of 1927, a record of similar scouting for the previous four years, thus covering a 5-year period. The results of scouting for the crop years between 1917 and 1926 will be found in the annual report for 1927.

TABLE 29.—Summary of pink bollworm scouting showing number of man-days scouting and number of infested fields for each of the districts scouted, 1923-1927

District	1923		1924		1925		1926		1927	
	Man-days	In-fested fields	Man-days	In-fested fields	Man-days	In-fested fields	Man-days	In-fested fields	Man-days	In-fested fields
Eradication areas:										
Hearne, Tex.	255	0	0	0	0	0	0	0	0	0
Trinity Bay, Tex.	1,225	0	1,046	0	787	0	828	0	1,025	0
Ennis, Tex.	740	0	835	0	606	0	566	0	842	0
Marilee, Tex.	611	0	612	0	237	0	283	0	418	0
Cameron, La.	718	0	655	0	649	0	661	0	533	0
Shreveport, La.	648	0	826	0	606	0	568	0	781	0
Infested areas:										
Pecos Valley, N. Mex. ¹	1,212	0	741	0	626	16	97	0	126	2
Pecos Valley, Tex.	421	5	650	15	183	22	32	8	1	6
Mesilla Valley, N. Mex.	231	0	158	0	155	0	47	2	303	6
Mesilla Valley, Tex.	0	0	140	0	17	1	1	2	0	0
El Paso Valley, Tex.	406	1	397	1	131	14	114	4	55	2
Big Bend, Tex.	66	36	167	62	(2)	96	(2)	(6)	(2)	(6)
Big Bend, Mexico.	2	3	(3)	2	0	(2)	(6)	(2)	(6)	(6)
Juarez Valley, Mexico.	0	0	0	0	2	3	27	0	0	0
San Carlos, Monclova, Mexico.	26	0	40	0	37	0	36	2	0	0
Deming, N. Mex.	1	0	0	0	15	0	34	3	2	1
Duncan Valley, Ariz. and N. Mex.	0	0	0	0	0	0	71	1	9	3
Gila (Safford) Valley, Ariz.	19	0	0	0	28	0	262	4	7	3
Cochise Co., Ariz.	0	0	0	0	11	0	160	10	20	4
Santa Cruz Valley, Ariz. ⁴	47	0	333	0	197	0	339	0	454	1
Western Extension, Tex.	39	0	16	0	746	0	967	0	2,534	24
Suspicious areas:										
Lower Rio Grande, Tex.	881	0	354	0	886	0	671	0	592	0
Lower Rio Grande, Mexico.	35	0	34	0	16	0	15	0	8	0
Other areas ⁵	1,793	0	444	0	436	0	1,198	0	926	0
Total	9,376	45	7,448	80	6,371	152	6,977	36	8,636	52

¹ Infestation in this valley was confined in the past to Carlsbad and vicinity and is referred to in certain previous reports as "Carlsbad" infestation.

² Research examinations.

³ Figures not available.

⁴ Includes plantings extending from Red Rock southward to Nogales.

⁵ Covers scouting done around centers in the Cotton Belt to which seed from infested areas had been distributed in the earlier years of the campaign of eradication. These areas were thoroughly investigated for a number of years afterwards without finding any infestation, but it seemed advisable to give them an intensive resurvey before releasing them from further consideration.

⁶ Heavy infestation; exact number of fields not recorded.

PREVENTION OF SPREAD BY CONTROL OF MOVEMENT OF CONTAMINATED ARTICLES

Under the provisions of quarantine No. 52 (revised) the control of the spread of the pink bollworm is attained through the enforcement of regulations requiring the sterilization of cottonseed at the gins, the compression and subsequent fumigation under vacuum of all cotton lint and linters, the movement under regulation of all cottonseed products, household goods and other things and substances likely to spread infestation through contamination, and the cleaning of railway cars from cottonseed and trash as a condition of their movement for any purpose out of the quarantined area.

During the year, 138,984 bales of cotton lint and linters were compressed and were fumigated under vacuum with hydrocyanic-acid gas. Of this

number 1,510 bales were produced in the Juarez Valley of Mexico, which is under regulations identical with those governing the regulated areas of the United States. Eight vacuum fumigation plants were in operation during the season, located as follows: Tucson, Ariz., Las Cruces, N. Mex., El Paso, Tex., two plants at Fabens, Tex., Maria, Tex., Pecos, Tex., and Roswell, N. Mex. Plants are now being constructed in the recently involved area at Lamesa and Big Spring, Tex.

DISINFECTION OF SEED AT GINS

Undoubtedly the most vital step for the local control and prevention of spread of the pink bollworm is to kill the insect in the cottonseed. In the cotton gins the cottonseed, in all infested areas, before being discharged, is heated to a temperature sufficient to kill the pink bollworm without injuring

germination. Such treatment is enforced in cooperation with this department by State authorities under State regulations, and all heating machines are visited at least once a day by inspectors. These machines are now operating at a higher efficiency than ever before, the average efficiency of the season being 91 per cent; in other words, for that proportion of the time the temperature was maintained at the required rate. Most of the balance of the time, even if at a lower rate, fairly effective results are obtained, and owing to occasional breakdowns and other unavoidable troubles, during which the recording device may continue to register, the actual efficiency is, as a matter of fact, higher than indicated. Continued improvement in seed heating will be in the direction of more accurately regulating the period of exposure to heat, and this will be given especial attention next year. It is estimated that approximately 69,492 tons of cottonseed were this year sterilized under the provisions of the pink-bollworm quarantine.

ROAD STATIONS

The necessity for inspection and control work to prevent the accidental or malicious movement of contraband articles likely to carry pink bollworm at road stations is well understood and is one of the important means of preventing the spread of this pest. During the year 19 road stations were operated, at the following places: Lordsburg (west-bound), Silver City, Roswell (two stations), Lake Arthur, Hagerman, Artesia, and Carlsbad, N. Mex., and Barstow, Girvin, Grand Falls, Buena Vista, Fort Stockton, Sanderson, Marathon, Alpine, Lobo, and Fort Davis, Tex., and Rice, Ariz. The stations at Hagerman, Lake Arthur, Carlsbad, and Artesia, N. Mex., and Barstow, Buena Vista, Grand Falls and Sanderson, Tex., were operated approximately one and one-half months only. A total of 96,614 cars was inspected, and from these 2,303 lots of material capable of carrying pink bollworm infestation were taken. Interceptions for the station at Rice, Ariz., are not included in these figures, as this station is operated by the State of Arizona. Four new stations have been established to intercept, as close to the point of origin as possible, movement of contraband material coming out of the heavily infested Big Bend areas. Three or four road stations will also be put in to intercept eastbound traffic from the recently involved area of the western extension.

INVESTIGATIONAL WORK

No important project such as the pink bollworm control can be carried out without certain incidental investigations of a research type being necessary, but in general all such necessary research work is being conducted in close cooperation with the agencies of the department directly concerned. During the year some careful fundamental investigations were conducted in connection with vacuum fumigation of cotton lint. The efficacy of vacuum fumigation of lint and linters has been very materially increased as a result of information secured through these investigations and the work gives promise of still further increasing the value of fumigation. The Bureau of Entomology has made arrangements to continue this work in cooperation with the board.

COOPERATION WITH MEXICO

At the present time the important cooperation which Mexico is giving has relation to cotton which is being produced near our border, more particularly in the Juarez Valley opposite El Paso, and very recently at Matamoros. It is important to us that the infestation on the Mexican side should be kept down as thoroughly as it is on the United States side of the river, and to accomplish this purpose, that all seed should be disinfected at the gin. Cooperation with the local Mexican authorities and cotton growers has brought about the installation of disinfecting apparatus at all gins, and our inspectors are permitted to supervise and enforce this control, with the result that all Mexican seed is being thus treated at a very high rate of efficiency. In return the Mexican lint is permitted to cross the border under bond for disinfection and compression and sale in the United States instead of being required as formerly to go by water route to some northern port of entry of the United States for disinfection as condition of entry. The safety under the existing controls of such locally grown Mexican cotton is on all fours with that produced on the United States side in the El Paso Valley.

The possibility of even more important cooperation with Mexico in our effort to control if not to eradicate the pink bollworm is promising, as a result of discussion of the subject with Mexican authorities and the clear indication of interest on their part and willingness to enter into any arrangement to this end which may seem to be practicable.

THURBERIA WEEVIL

During the crop year 1927 there were no important changes in the known status of the *Thurberia* or Arizona boll weevil. The necessity of protecting the irrigated and dry-land cotton areas from this pest was again emphasized by the investigations of the Bureau of Entomology which indicate the ability of this native variety of the boll weevil to adapt itself immediately and fully to cultivated cotton.

The importance of the *Thurberia* weevil is due to its threat to cotton production in those drier portions of the Cotton Belt where it can survive periods of heat and drought fatal to the well-known Mexican cotton boll weevil. The latter is limited in its possible spread westward, by its inadaptability to arid conditions; but if the *Thurberia* weevil succeeds in spreading throughout these drier areas, the growers of western Texas, New Mexico, and Arizona may face losses from its work equal to those which the older and better-known variety of boll weevil has brought about in the Southeastern States. The department in cooperation with the State of Arizona is endeavoring to prevent its dissemination to other localities from the southeastern counties of that State where it feeds on the *Thurberia* plant and has spread to many of the cotton fields.

The most important development in this work during the past year was the dissolution of the injunction which had been granted November 19, 1926, prohibiting the Secretary of Agriculture, the Federal Horticultural Board and their agents from carrying out the provisions of quarantine 61 as applied to the Postvale area. The court decided that—

The act of Congress having conferred upon the Secretary of Agriculture the power and duty to find facts and determine conditions upon which the operation of the statute depends, such findings and determination can not be judicially reviewed in the absence of a showing that he acted arbitrarily or unfairly, or that there was not evidence to support such finding and determination.

The plaintiff's applications (1) that the Secretary of Agriculture be enjoined from the enforcement of the quarantine regulations, and (2) that the Southern Pacific Railroad be enjoined from refusing to receive and ship his cotton and cotton seed without compliance with said quarantine order and the regulations thereunder with respect to fumigation and sterilization, were both denied, and judgment entered for the defendants—the Secretary of Agriculture and the railroad company.

Scouting for the *Thurberia* weevil in Arizona totaled 1,092 man-days. Scouting for the pink bollworm and *Thurberia* weevil in Arizona was conducted simultaneously and practically all of this scouting which was done in the *Thurberia* weevil-infested areas and in areas in close proximity thereto, was carried on either by trained inspectors of the Bureau of Entomology or else under their close supervision. The weevil was found to be quite generally distributed in all cotton plantings south of Tucson and it was also found without difficulty in the cotton plantings just north of that city.

With the changing of the requirements for the treatment of cotton lint and linters which were made in the last revision (July 9, 1927) of quarantine 61, the methods of preventing the spread of this pest are the same as those used for the pink bollworm.

The heating of cottonseed was conducted at the high average efficiency of over 95 per cent. Approximately 5,336 tons of cottonseed were sterilized under the provisions of the quarantine during the course of the season and 10,672 bales of cotton lint and linters were compressed and subsequently fumigated under vacuum with hydrocyanic-acid gas. As in the case of the pink bollworm quarantine, compression is an added requirement effective the first time this year.

At road stations operated at Picacho and Tucson (two stations), Ariz., and Lordsburg, N. Mex. (eastbound), 70,651 cars were inspected from which 2,722 lots of materials capable of carrying infestation were confiscated.

The records of eastbound interceptions of the Lordsburg, N. Mex. station are included because these are made solely to prevent eastward carriage of the insect out of the *Thurberia* weevil area of Arizona which extends practically up to the New Mexico line.

QUARANTINE ON DOMESTIC NARCISSUS

The enforcement of the quarantine regulations governing the interstate movement of narcissus bulbs has been carried out for the board by the plant-inspection services of the various States. The last annual report presents a table of the number of narcissus inspections reported to the department from January 1, 1927, to October 1, 1927. At the time the present report is being prepared, the results of the field inspection for the season of 1928 have not yet been received and the second or storage inspection of the bulbs has not yet been completed.

The regulations supplemental to the quarantine were amended effective May 15, 1928, making certain changes in shipping restrictions and modifying the treating requirements in cases where bulb flies but no eelworms were discovered on inspection. The important features of the regulations previously in effect, including the requirements of both field and crop inspections, and treatment in case any infestation is found in the plantings, were retained.

DATE SCALE ERADICATION

The very promising outlook for the completion of the eradication of the Parlatoria date scale from the United States, as presented in the last annual report, received a setback during the latter part of 1927 when several new date-scale infestations were discovered in California and Arizona. These outbreaks were sufficiently serious, in the belief of the growers and of date experts of the department, to threaten the future of the date industry in the United States if not properly controlled.

To meet this emergency, a supplemental appropriation of \$25,000 was included in the deficiency bill of December, 1927, the amount to remain available until June 30, 1929, and the control work was completely reorganized. An agent of the Bureau of Entomology thoroughly experienced in eradication work, B. L. Boyden, was transferred from the truck crop insect investigations office to the board, to take charge in the field, with headquarters at Indio, Calif. The first object under the new organization was to make a complete and thorough census and inspection of the date plantings, commercial and other, in the States concerned—California, Arizona, and Texas—with the object of disclosing the existing extent of scale infestation as a basis of determination of the future program of eradication work. It developed that it had never been possible, under the previous appropriations and personnel, to make such a general survey—a situation which was very unfavorable to any eradication program. Along with the present survey it was proposed that preliminary clean-up work should be done, including all isolated trees or minor points of infestation, and that the more important infestations should be cleaned up as rapidly as possible without, however, interrupting the progress of the fundamental survey work.

Under this plan, surveys have been made and clean-up work undertaken

throughout the Coachella and Imperial Valleys in California and in the date areas in Arizona. The areas in Texas have not yet been reached. In the Coachella Valley some 136,000 date palms have been located and inspected. Of these, 1,044 located on 19 different properties were found infested. Twelve of these properties had been considered free from scale, while on the remaining 7, eradication operations had been in progress for a considerable period. In the Imperial Valley, inspections were made of 2,700 palms, and infestations were found on 77 of these trees located on 11 different properties. The scouting in the north end of the Imperial Valley in the Calipatria district has been more encouraging, none of the 4,037 palms so far located having been found infested. In the Salt River Valley of Arizona surrounding Phoenix approximately 15,000 palm inspections were made and 84 palms on 9 properties were found infested. In the Yuma district of Arizona 24,000 palm inspections were made and 5 infested palms were found. These infested palms were all door-yard plantings in the city of Yuma.

Heavily infested palms were found in these various areas constituting centers of infestation. In many cases lightly infested palms were found in the vicinity of the centers of infestation showing the tendency to spread. The type of inspection necessary to discover light infestations for treatment before they become centers of infestation is difficult and slow.

Except in the Imperial Valley, the infestation determined has been less than 1 per cent of the number of trees or palms inspected. The indications from the survey as so far completed are on the whole favorable to the possibility of ultimately eradicating the scale, but it is clear that such eradication will involve much greater cost than has hitherto been estimated.

The method of eradication consists in defoliating the trees and torching them with a gasoline torch. Some 5,600 palms were given this treatment during the progress of the survey. Many of the torched trees were not actually determined as infested but were adjoining or close to trees on which scale had been discovered. In the case of certain infested plantings which had been abandoned and were considered no longer of commercial value; all of the trees—some 2,500—were dug out and destroyed.

An effort is being made by the date specialists of the Bureau of Plant Industry to encourage the establishment

of scale-free date plantings in certain new districts in the Southwestern States. All palm offshoots shipped to these points are given the heat treatment described in my last annual report.

MEXICAN FRUIT WORM

The control of the Mexican fruit worm outbreak in the lower Rio Grande Valley, which threatened the very important citrus development of that region, has been most successful. The enforcement of quarantine restrictions and drastic clean-up and eradication work have apparently prevented any reappearance of the fruit fly in this district, and the very large crop of 1927-28 has been harvested without the finding of a single infested fruit. This outcome seems to indicate the possibility of protecting this industry indefinitely by a continuation of the measures now being enforced. It was possible to obtain this very gratifying result only by the active cooperation in the enforcement of quarantine regulations and clean-up measures by State authorities, and more particularly by the extraordinary self-sacrifice of the citizens of the district. This cooperation concerned particularly the destruction of all fruit ripening during the seven months so-called starvation period during which it was the intention that no fruit should develop or remain on any trees at a stage which would be attractive to the pest.

The situation relative to this fruit worm and the control measures were rather fully discussed in my annual report for the fiscal year ended June 30, 1927.

Following the original discovery of the pest by authorities of the State experiment station and the reporting of this finding directly, and also through the Texas State Department of Agriculture to this department, control work was immediately instituted. In the absence of any available board funds and the apparent impossibility of obtaining any until Congress should be again in session, clean-up and control work was undertaken by a temporary detail of leaders and inspectors from the pink-bollworm forces in Texas—a procedure believed to be fully warranted by the necessity for immediate action. In the prosecution of this work the department had the active cooperation of the Texas State Department of Agriculture. The first step was the clean-up or destruction of ripe citrus and all other fruit, beginning May 1, 1927, and this was followed by the maintenance of a nonfruit zone during the summer of that year. Later on it

was found possible to make certain adjustments of funds in the Bureau of Entomology by which \$30,733 were assigned to the division of the bureau in charge of fruit-worm investigations, and thus made available to carry out this control project. Much of the personnel which had already been detailed from the board was transferred to the rolls of the bureau September 16, and from that time until the emergency appropriation of \$100,000 made in the first deficiency bill of 1928 became available, December 22, 1927, the field direction of the work was conducted by the bureau under the general direction of the board. The special emergency appropriation was also assigned to the bureau for the continuation of the work for the balance of the fiscal year to avoid the necessity of a reshuffling of personnel and accounts in the midst of the shipping season. It was provided, however, that the full control of the work should be taken over by the plant quarantine and control administration with the beginning of the fiscal year 1929. To give continuity to the record of quarantine and control work on account of this fruit fly, the report of the work for the fiscal year 1928 is included in its entirety in the report of the board.

The important operations of the present fiscal year included (1) the completion of the enforcement of the nonfruit period from July 1 to September 30; (2) the inspection and certification of citrus fruit for the winter shipping period, October to February, inclusive; and (3) the enforcement again of the nonfruit period beginning March 1. In the conduct of these various operations, the same very general and loyal cooperation on the part of the officials of the Texas State Department of Agriculture and of the citizens of the district has characterized the work.

FRUIT MOVEMENT

In connection with the citrus crop of 1927-28, marketed in the five months October to February, all movement of fruit was based on Federal inspection and certification, and such inspection and certification was further conditioned on safeguards and requirements pertaining to groves and premises, grading of fruit, disposal of culls, and the maintenance at all packing plants, subject to the examination by inspectors, of complete lists of all consignees, together with records of the amount and date of each shipment. Each or-

chardist was also required to keep his grove free from dropped fruits, rubbish, and weeds during this season, and to dispose of all fallen and discarded fruit either by burning or by burial to such depth as would prevent the escape of any fruit flies. In addition, a regular monthly inspection of citrus groves was carried out during the shipping season to determine the freedom of the groves from possible infestation. The extent of the work of grove inspection is indicated by the fact that there are now in

the district some 477,000 grapefruit, orange, and other citrus-fruit trees in bearing. In connection with these inspections, a census was made of citrus plantings in the district, which is incorporated here in Table 30 as indicating the probable future increase of inspection and control work. An incidental benefit from the quarantine requirements is that the destruction or other utilization of culls and grading of the fruit has increased the demand and improved the market for the fruit.

TABLE 30.—*Citrus census of the lower Rio Grande Valley of Texas, taken in summer of 1928*

County and fruit	The number of growing citrus trees of different ages ¹						Total
	0	1	2	3	4	5	
Cameron County:							
Grapefruit.....	253,709	149,153	111,027	106,619	69,659	142,684	832,851
Oranges.....	88,582	69,300	63,754	65,251	45,000	53,640	385,527
Other citrus ²	1,820	2,283	3,288	4,704	3,182	7,954	23,231
Total.....	344,111	220,736	178,069	176,574	117,841	204,278	1,241,609
Hidalgo County:							
Grapefruit.....	646,888	304,889	181,813	136,363	79,075	193,109	1,542,137
Oranges.....	184,015	110,093	90,809	72,571	34,138	60,830	552,456
Other citrus ²	5,284	3,298	5,272	5,584	3,684	13,227	36,349
Total.....	836,187	418,280	277,894	214,518	116,897	267,166	2,130,942
Willacy County:							
Grapefruit.....	15,737	4,190	4,244	1,680	92	2,715	23,658
Oranges.....	7,701	1,707	2,871	980	214	1,922	15,395
Other citrus ²	534	136	363	292	107	1,121	2,553
Total.....	23,972	6,033	7,478	2,952	413	5,758	46,606
Total for all counties:							
Grapefruit.....	916,334	458,232	297,084	244,662	148,826	338,508	2,403,646
Oranges.....	280,298	181,100	157,434	138,802	79,352	116,392	953,378
Other citrus ²	7,638	5,717	8,923	10,580	6,973	22,302	62,133
Grand total.....	1,204,270	645,049	463,441	394,044	235,151	477,202	3,419,157

¹ In the table the ages of trees are classified as 0, 1, 2, 3, 4, and 5. Trees given under classification 0 were planted during, or at the beginning of, the growing season 1927-28. Trees given under classification 1 were planted during, or at the beginning of, the growing season 1926-27. The ages of trees designated as 2, 3, and 4, respectively, will be understood in the light of this explanation. Trees given under classification 5 are 5 years old or older.

² Under this classification is included kumquats, limes, mandarins, satsumas, sour oranges, tangelos, tangerines, lemons, etc.

Permits were issued to 494 concerns for the packing of grapefruit, oranges, and kumquats, and 654,130 shipping tags were supplied to them. Railroad reports indicate that 1,144 carloads of citrus fruit were shipped out of the lower Rio Grande Valley during the season. In addition to this, approximately 190 carloads of fruit were sent by express, and possibly some 200 carloads by truck and mail, or carried out by tourists. This would indicate a total crop movement out of the area during the season of approximately 1,534 carloads.

ERADICATION MEASURES

The drastic program of eradication involving the enforcement of the starvation period each season for seven months, from March 1 to September 30, as well as the repeated inspection of citrus groves and control of movement of fruit must be carried out as long as infested fruit continues to be brought to nearby Mexican markets or as long as there is any infestation on the Mexican side of the border. The maintenance of the important citrus industry which has grown up in the

lower Rio Grande necessitates the acceptance indefinitely by the residents of that district of the hardship of the loss of summer fruit. The particular purpose of the maintenance of a nonfruit period is to prevent any of the parent fruit flies, which may cross the border or any flies which may emerge from infested fruits illegally carried over from Mexico, from finding host fruits available for infestation and breeding.

The first step in the enforcement of fruit fly eradication for 1928 was an educational campaign to secure the prompt removal prior to the end of February of all citrus fruit remaining on the trees; and this effort, due to full cooperation, was successful. The next step was the elimination of other fruits ripening during the following seven months' period. There were in the area approximately 35,000 peach, plum, and other host fruit trees of varieties normally ripening during the summer period. Under the regulations, owners were permitted either to remove the green fruit from such trees before it began to ripen, or to destroy the trees themselves. The constant difficulty and annoyance of removal of ripening fruit, let alone the vast amount of inspection and follow-up involved, can easily be appreciated. An effort has, therefore, been made to rid the citizens of the district once for all from this annoyance and difficulty and disappointment by encouraging them either to destroy the trees themselves, or to permit them to be uprooted and destroyed. Approximately 75 per cent of the trees have been thus removed and, in the case of the others, the fruit is being destroyed. It seems probable that all such trees will be eliminated in the near future. For the success of such elimination, it is clear that the citrus-fruit industry of the district is tremendously indebted to many citizens not directly interested in the returns from the crop or the future of the industry.

Deserving of even higher commendation and praise in this connection is the hearty cooperation of Mexican officials and residents on the Mexican side of the border. The presentation of the desirability of a similar clean-up of fruits in Matamoros and along the border opposite the citrus-growing area of Texas led to an immediate and favorable response from the appropriate Mexican officials, with the result that a clean-up was made on the Mexican border, beginning with the Gulf of Mexico and extending nearly 100 miles up the river. Inspectors of the Mexi-

can Department of Agriculture, accompanied by laborers, made a house-to-house canvass throughout the towns and villages of this section and also the farms and ranches, to destroy the host fruit. The total amount of fruit picked in Mexico in this work is estimated at upwards of 750,000 fruits, chiefly oranges, peaches, and guavas. In a number of instances, individuals were fined in Mexican courts because they had not removed the summer host fruit. It should be emphasized that there is no fruit industry of importance on the Mexican side, and that the fruit concerned is merely little garden plantings for home use, and that, therefore, this action on the part of Mexican officials and the cooperation of Mexican citizens was a purely friendly and neighborly act.

NEW AND REVISED PLANT QUARANTINES

DOMESTIC

The following quarantines have been either promulgated or revised during the year:

The white-pine blister-rust quarantine was amended February 20, 1928, by adding the State of Idaho and four counties in Oregon to the area designated as infected, and by making certain other minor changes in the regulations.

The European corn-borer quarantine was amended August 6, 1927, to simplify the conditions governing the movement of shelled corn; revised December 29, 1927, by extending the areas under regulation in the States of Michigan, Indiana, Ohio, Pennsylvania, New York, New Jersey, Vermont, Massachusetts, Rhode Island, and Maine; and amended May 21, 1928, by adding to the regulated area all that part of New York State not theretofore included.

The Japanese-beetle quarantine was amended August 3, 1927, by requiring inspection and certification of farm products and cut flowers grown in the infested area shipped interstate by boat from New York City; October 28, 1927, by extending the area under regulation in the States of Pennsylvania, New York, and Connecticut; and April 18, 1928, by adding mushrooms and broomcorn to the list of articles exempted from regulation, and by requiring certification of regulated farm products and cut flowers shipped interstate by boat from the markets of New York City irrespective of origin.

The pink-bollworm quarantine was revised July 9, 1927, to include the State

of Arizona; to add the counties of Grant, Hidalgo, and Luna in New Mexico to the regulated area; and to require compression as well as disinfection of cotton lint as a condition of interstate movement; and amended April 18, 1928, to add the counties of Winkler, Andrews, Ector, Crane, Upton, Midland, Martin, Dawson, and Glasscock, and portions of Borden and Howard in west-central Texas, to the regulated area.

The *Thurberia*-weevil quarantine was revised July 9, 1927, to include all of Cochise and part of Graham Counties, Ariz., in the regulated area, to require the compression as well as disinfection of cotton lint as a condition of interstate movement, specifying the conditions for interstate movement of cottonseed cake and meal, bagging and other containers of cotton, farm household goods, farm equipment, and other articles contaminated with cotton, and prohibiting the interstate movement of the *Thurberia* plant from any portion of Arizona.

The satin-moth quarantine was amended October 18, 1927, to extend the areas designated as infested in the States of Maine, New Hampshire, and Massachusetts.

The Mexican fruit-worm quarantine was promulgated August 10, 1927, restricting the interstate movement from the counties of Cameron, Hidalgo, and Willacy, Tex., of host fruits in the raw or unprocessed state.

FOREIGN

The European corn-borer quarantine was amended July 5, 1927, to provide for the entry, under permit and in compliance with the requirements of the regulations, of green sweet or sugar corn on the ear.

The quarantine against Christmas trees and greens from portions of the Province of Quebec, Dominion of Canada, which has been in force since July 1, 1924, was revoked June 27, 1928, effective July 1, 1928. This action was made possible by the determination of the fact that the gipsy moth has been

apparently eradicated in the Province of Quebec.

TERMINAL INSPECTION OF MAIL SHIPMENTS OF PLANTS AND PLANT PRODUCTS

The terminal inspection points in Oregon, Mississippi, and Arizona for the inspection of mail shipments of plants and plant products under the authority of the act of March 4, 1915, were revised during the year. No additional States inaugurated terminal inspection during the fiscal year 1928. California, Arizona, Montana, Florida, Washington, Arkansas, the District of Columbia, Mississippi, the Territory of Hawaii, Utah, Oregon, Georgia, Idaho, and Oklahoma, in the order named, had previously availed themselves of the provisions of the terminal inspection act.

CONVICTIONS AND PENALTIES IMPOSED FOR VIOLATIONS OF THE PLANT QUARANTINE ACT

The following convictions and penalties imposed for violations of the plant quarantine act were reported to the board during the year:

White-pine blister-rust quarantine: Three convictions, with fines aggregating \$185.

Japanese beetle quarantine: Twenty-four convictions, with fines aggregating \$757.

Mediterranean fruit fly and melon fly quarantine: One conviction, with fine of \$25.

Quarantines affecting Mexican products: Four convictions, with fines aggregating \$125. Fines aggregating \$679 were also imposed by customs officials on the Mexican border against 131 persons caught in the attempt to smuggle in from Mexico prohibited plants and plant products. Another person, who attempted to smuggle in certain prohibited fruits, was excluded from the United States by the immigration board for at least one year.

NOV 19 1928

EXPERIMENT STATION FILE

REPORT OF THE FOOD, DRUG, AND INSECTICIDE ADMINISTRATION

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOOD, DRUG, AND INSECTICIDE ADMINISTRATION,
Washington, D. C., June 30, 1928.

SIR: I beg to submit herewith the report of the work of the Food, Drug, and Insecticide Administration for the fiscal year ended June 30, 1928.

Respectfully,

WALTER G. CAMPBELL,
Director of Regulatory Work.

Hon. W. M. JARDINE,
Secretary of Agriculture.

INTRODUCTION

June 30, 1928, completes the first year of the operations of the Food, Drug, and Insecticide Administration, established by act of Congress to conduct the work necessary for the enforcement of the food and drugs act, the tea act, and the naval stores act, formerly enforced by the Bureau of Chemistry, the insecticide act, formerly enforced by the Insecticide and Fungicide Board, and the import milk act and the caustic poison act, which went into effect after the administration was created. The nature of these laws is such that at least half of the administration's activities must be carried on outside of Washington at stations strategically located throughout the United States. Somewhat more than half of the personnel is assigned to these stations.

The year's work has demonstrated the advantages of the reorganization, the principal purpose of which was to set up a law-enforcement machinery divorced from research activities having no regulatory bearing. The new arrangement makes it possible for the Washington force and the field force to proceed with a single objective, unhampered by the demands of unrelated research, which, of necessity, slow down regulatory operations, and at the same time to carry on investi-

gations that bear on regulatory activities and are necessary for effective law enforcement.

In enforcing the six statutes entrusted to it, the administration has attempted to adopt a constructive attitude. Observations through more than 20 years of law enforcement have demonstrated convincingly that only an insignificant proportion of the members of the industries concerned deliberately violate the law. Most of them earnestly desire to comply with all reasonable regulations, not only on ethical grounds but also because it is the part of good business. Recognizing this, the department has chosen to regard the six laws as corrective rather than punitive, and has adopted an advisory-before-the-act attitude by offering constructive suggestions which should enable manufacturers to keep their products in compliance with the law. It has not hesitated, however, to initiate proceedings under the law in those instances where the protection of the consumer or negligence or willfulness on the part of the shipper indicated such action to be proper.

No better illustration of the working out of this policy can be given than to cite the activities under the food and drugs act, discussed in earlier reports, involving canned blueberries, canned tomatoes, and citrus fruit—choosing at random commodities char-

acteristic of different parts of the country.

Some years ago it was discovered that the Maine blueberries were so heavily infested with worms that it became necessary to prevent the distribution of many lots of the canned fruit by instituting seizure action. As blueberry canning is one of the vital industries of Maine, giving a livelihood to a large part of the population in at least one county, the possibility of having the output of many of the canneries seized was a serious prospect. Accordingly experts were sent into the field to study the problem at first hand. As a result a method was devised whereby the wormy and otherwise unfit fruit could readily be removed from the berries delivered to the canneries, leaving only those that were fit for canning. The simple and effective piece of machinery developed for this purpose has been almost universally adopted by the Maine blueberry packers. Cooperative efforts by the Federal and State officials have since that time insured a high-quality pack of blueberries in Maine.

Twenty years ago the manufacturing methods employed by most producers of catsup and tomato sauce were so crude that the final product usually contained a large proportion of decomposed tomato material. A method was developed for the detection and estimation of decomposed matter in the finished article. The packers were educated in the use of this method, so that it now serves as a guide to them in perfecting their packing processes. In furthering this educational plan Federal and State officials in certain sections, like Indiana, where tomato products are packed on a large scale, hold classes at which representatives of the canners may become familiar with the Government's methods of inspecting tomatoes and tomato products to insure the use of only such material as is fit for food.

Disastrous freezes have worked havoc in the citrus orchards of Florida and California. Although the effect of a severe frost is not immediately apparent in the uncut fruit, the edibility of frosted fruit is seriously affected by a more or less complete drying of the tissues by the time it reaches the consumer. Far-sighted packers were quick to recognize the danger of the loss of their markets if public confidence in the quality of the citrus fruit were shaken. However, those interested only in the immediate dollar,

who, unfortunately, seem to be present in every industry, were disposed to take a chance and continue their shipments. The industry thereupon appealed to the administration to maintain, in cooperation with State authorities, that supervision which would preclude the necessity for making frequent seizures on the markets, with subsequent damage to the reputation of the industry as a whole. State assistance, which checks at its source the shipment of frosted fruit, is of great value in law enforcement. As a result of this cooperative effort, very little unfit fruit was shipped during 1928.

This constructive work, which has been of great value in carrying out the terms of the food and drugs act, has met with the enthusiastic approval of the industries. It is not now apparent, however, how the field of constructive endeavor can be greatly enlarged. The Food, Drug, and Insecticide Administration to-day is operated on essentially the same financial basis as was the corresponding law-enforcement unit of the department in 1914, notwithstanding the fact that during the intervening 14 years there has been a vast increase in the cost of carrying on the work and in the output of commodities shipped within the jurisdiction of the law. The present control is maintained only by the utmost exertion on the part of the personnel and by the strictest economy, made possible by the adoption of the project system, which was described in detail in the report of the chemist for 1928. No matter how effectively abuses in any particular line of products may be controlled, improved conditions can be maintained only by strict supervision. The instant supervision is withdrawn abuses begin to creep in and multiply, until ultimately conditions may be only slightly better, if better at all, than when control measures were initiated. The present limited organization can hardly enlarge upon the constructive work already undertaken.

FOOD AND DRUGS ACT

The Federal food and drugs act makes illegal the shipment in interstate commerce, the sale in the Territories or the District of Columbia, or the importation into the United States or exportation from it of any misbranded or adulterated food or drug. During the year the text of the act and the regulations for its enforcement were reissued as Service and Regula-

tory Announcements, Food and Drug No. 1.

The work under this law was carried on along the lines followed during the last few years. Through cooperation with the members of the trade and with State officials every effort was made to correct abuses at their source, and when such efforts were unsuccessful court action was instituted to prevent the interstate shipment of products that failed to comply with the law.

DOMESTIC FOODS AND DRUGS

During the year just ended 1,015 prosecution and seizure actions were brought against domestic products under the food and drugs act, as compared with 953 during the preceding year. Table 1 summarizes these actions.

TABLE 1.—*Summary of prosecutions and seizures under the food and drugs act during 1928*

	Prosecution	Seizure	Total
Alimentary pastes.....		2	2
Baked products.....	8	16	24
Beverage materials.....	2	10	12
Cacao products.....	1	12	13
Cereals.....	1		1
Coffee.....		1	1
Confectionery.....		4	4
Dairy products:			
Butter.....	54	104	158
Cheese.....	2	9	11
Milk (condensed).....		2	2
Drugs and drug products:			
Cod-liver oil.....		4	4
Crude drugs.....	2	5	7
Remedies.....	54	162	216
Stock remedies.....		7	7
Eggs:			
Shell.....	3	3	6
Frozen.....		12	12
Fish.....	1	10	11
Flavoring extracts.....	1	2	3
Flour.....	1	3	4
Fruit and fruit products:			
Fresh fruit.....	39	12	51
Canned fruit.....	5	25	30
Dried fruit.....	2	77	79
Jams, jellies, and preserves.....	5	6	11
Gum.....		1	1
Honey.....		1	1
Nuts.....		27	27
Oils.....	9	34	43
Oleomargarine.....		1	1
Poultry.....		11	11
Shellfish.....	13	8	21
Sirup.....		3	3
Soup.....	1		1
Spices and condiments.....	1	14	15
Stock seeds.....	50	62	112
Vegetables:			
Fresh.....	1	1	2
Canned.....	11	47	58
Vinegar.....		42	42
Water.....		8	8
Total.....	267	748	1,015

The consummation of a court case is brought about jointly by the field force and the Washington staff. Members of the various stations of the three districts are responsible for the findings at the factories, for the analyses of the samples, and for the assembling of the evidence necessary for presentation in court. The specialists in Washington check up on the reports from the field and determine the action to be taken.

The decrease in the actions involving alimentary pastes to 2 in 1928 from 25 brought in 1927 shows that the efforts to prevent the shipment of noodles containing no egg, but colored to indicate the presence of egg, have been successful.

The marked falling off in the actions involving fresh fruit, from 167 in 1927 to 51 in 1928, shows the salutary effect of last year's efforts to prevent the shipment of frosted citrus fruit. Disastrous freezes occurred in Florida in both of these years.

A special campaign to keep from the market figs containing excessively high proportions of moldy and wormy fruit resulted in a large number of cases against this product. The administration joined forces with the Bureau of Chemistry and Soils, the Bureau of Entomology, the Bureau of Plant Industry, the University of California, and the producers in an effort to determine the cause of the deterioration of the western fig crop and the steps to be taken to prevent the shipment of worm-infested and moldy fruit.

More than the usual attention to interstate traffic in vinegar was necessary because rather widespread and persistent violations had become prevalent in certain sections of this industry.

Supervision of interstate traffic in fruits and vegetables that are subject to contamination with spray residue has been continued. As a result of a conference, held in Salt Lake City in February, 1927, of representatives of the western apple industry, State food and horticultural officials, and members of this department, extremely close cooperation has existed between all agencies concerned in keeping spray-contaminated fruit from the market. The industry has endeavored to put into general use the specially devised methods for removing excessive residues advocated by State and Federal officials, and State officials have restricted the movement out of the States of fruit not properly

cleaned. When, in spite of the efforts of the industry and the State authorities, fruit bearing excessive residues has been shipped, it has been intercepted and removed from the channels of trade by agents of the administration. As a result of this concerted stand against the shipment of contaminated fruit there is at present no reason for apprehension regarding the spray residue content of American fruit. The same may be said in regard to vegetables. Unremitting efforts on the part of the industry and continued supervision by control officials, however, will be necessary to make permanent this satisfactory condition.

The shellfish industry always constitutes one of the major projects of the eastern district. In an effort to put an end to interstate traffic in oysters containing excessive water from the floating to which they were subjected, the department, in June, 1927, issued Food Inspection Decision 211, which stated that the floating of oysters as commonly practiced has the effect of adulterating the product with water, making illegal the shipment of such shellfish within the jurisdiction of the food and drugs act. Field work conducted during this fiscal year has shown that oysters adulterated with water incorporated through floating and also through faulty methods of washing are still being shipped. Inspection trips have been made to point out improper practices, and legal action has been instituted to induce the packers to abandon the shipment of oysters adulterated with water.

A survey of crab-meat packing establishments in Maryland and Virginia in August, 1927, brought to light various practices that were bound to make the finished products illegal. Of the hundreds of cultures obtained during this investigation several were identified as pathogens and members of the paratyphoid group of bacteria. These organisms apparently were of animal origin, indicating contamination from rodents, flies, etc. No serious violations either as to the grades of meat put up or the net weight delivered for shipment were noted. The results of this survey were brought to the attention of the State food officials having jurisdiction over the shellfish packing establishments in the two States concerned. A resurvey of the plants in 1928 showed that the packers, acting upon the suggestions of Federal and State officials, had very generally removed the sources of con-

tamination to which their attention had been directed.

Butter and stock feeds received the attention usually accorded them. Close watch each year must be kept over these staple products to prevent traffic in low-fat and high-moisture butter and in stock feeds that do not have the protein content claimed for them or have too high a proportion of worthless ingredients, such as chaff and hulls. A new violation of the law encountered this year was the sale of cull-stock poultry consisting of decomposed or diseased fowls and those that had died otherwise than by slaughter.

New causes for proceeding against cereal products and baked foods developed this year through the discovery that they were being labeled as of value in maintaining, promoting, or restoring health, or in acting directly as therapeutic agents in the treatment of disease, when such claims were not warranted by the composition. Under the law medicated foods, such as chewing gum to which phenolphthalein has been added, crackers containing senna, cereals with added agar-agar, mayonnaise made with mineral oil, and candy containing iodide, must be offered for sale as medicines, not as foods. Steps have been taken to prevent the marketing of such products unless the labelings indicate very clearly that the articles in question are medicines.

Falsely labeled medicinal products always give rise to many legal actions. Remedies for man and beast are constantly being labeled as capable of producing therapeutic effects which are impossible of fulfillment by the ingredients alone or combined.

The cooperation between the administration and the drug industries, which has been rapidly growing during several years, has made it possible to curtail many abuses in the traffic in drugs and drug products. Particularly noteworthy is the improvement of hypodermic and compressed tablets. A survey in 1923 showed that 34 per cent of the samples examined failed to comply with the official standards. A survey this year showed only 8 per cent to be substandard.

The growing spirit of cooperation on the part of manufacturers of proprietary medicinal preparations has made it possible to bring into compliance with the law the labelings for a large number of these preparations without contests in the courts. A uniform.

scheme for criticizing labels from the standpoint of therapeutic claims appearing on them has been adopted. At the instance of the administration, manufacturers of most tooth pastes have taken steps to delete from their labels unwarranted therapeutic claims, such as statements that the use of a paste will cure pyorrhea.

The cases against cod-liver oil preparations were the result of an effort to insure truthful labeling of products of this kind. A number of large dealers in cod-liver oil preparations, such as cod-liver oil tablets, which examination has shown to be generally worthless, have been induced either to discontinue the sale of such so-called cod-liver oil substitutes or to remove from all labeling the misleading statements indicating the presence of true cod-liver oil or cod-liver oil vitamins.

Investigations having shown that some of the so-called antiseptics on the market have little or no real antiseptic power and that others, although antiseptic under certain conditions, are virtually worthless when in contact with body fluids, efforts were made to bring about a drastic revision of the labeling employed in this part of the drug industry. A ruling was issued that products, such as salves, ointments, and dressings, that remain in contact with the body for long periods of time may be designated as antiseptics if they inhibit the growth of bacteria, but that products like mouth washes, douches, and gargles, that are in contact with the body only for brief periods may properly be designated as antiseptics only if they will destroy bacteria under the conditions of use; that is, in the dilutions recommended and in periods of time comparable to those in which they would have an opportunity to act when used as directed.

IMPORTED FOODS AND DRUGS

The food and drugs act provides for the inspection of foods and drugs offered for entry into the United States. The invoices covering the shipments and sample cases are made available for inspection at the time they are being examined by appraisers of merchandise in accordance with the provisions of the tariff act. All invoices and shipments are inspected, but samples are taken only from lots that are suspected of being adulterated or misbranded. Although samples of every shipment of certain commodities are taken, the condition of others can

be accurately determined by taking comparatively few samples, owing to past experience with the same products and to a knowledge of the practices of the shippers concerned. From time to time, however, each field is fully covered.

The act provides that products offered for entry may be delivered to the importer under bond, pending results of examination, and provides for the exclusion of all adulterated or misbranded goods. A product that is misbranded, though not grossly, or adulterated, though not seriously, may often be brought into compliance with the law by relabeling or renovating. When this has been properly done and reinspection shows that the product meets the requirements of the law, the shipment may be released. This privilege of relabeling or renovating is not granted when the adulteration or misbranding is of a serious nature or when the shipper has been found guilty of repeated violations of the act.

Although a large number of imported foods and drugs have been examined during this fiscal year, in most products the number of cases involving the more serious violations of the law has been somewhat smaller than in the past.

Figs are subject to deterioration from attack by larvæ or mold. A thorough examination of all shipments of figs offered for entry led to the detention of a relatively larger number of shipments than had been necessary in past years.

As a rule, dates are not very subject to deterioration from the action of larvæ or mold, and in most years the number of shipments detained has been extremely small. During the year just ended, however, the number of shipments detained for this reason, although not large, has been decidedly greater than in most past seasons, owing apparently to the fact that part of the shipments had been handled somewhat less carefully than usual.

A large number of fruit or vegetable products that are sometimes colored green with copper salts or by the action of copper vessels were examined. Most of these goods proved to be entirely free from copper, or to bear only slight traces. Particular attention was given to several shipments of candied citron and orange or lemon peel. The output from most of the firms shipping these products contained only a slight trace of copper, but that from one or two firms contained enough to cause detention.

The crude drugs of many kinds shipped into this country in large quantities during the year showed a general improvement over those imported during past years. The number of detentions on the ground of the presence of dirt, foreign material, or substitute material fell below those of other years. Crude drugs which are required by the United States Pharmacopœia to meet a specific physiological assay were subjected to very careful scrutiny. Every shipment of ergot offered for entry was fully examined and assayed. On the whole, the ergot brought in this year was found to be of much better quality than that brought in during 1926-27. As compared with the detentions made last year because of deficiencies in potency and for failures to comply with other pharmacopœial requirements, the detentions this year for the same causes were very few.

A concerted effort was put forth this year to make sure that all the cod-liver oil permitted entry into this country was of suitable quality and purity.

FOOD STANDARDS

The definitions and standards for food products adopted by the officials of the department as a guide in enforcing the food and drugs act are drawn up by the food standards committee, composed of representatives of the United States Department of Agriculture, the Association of Dairy, Food, and Drug Officials of the United States, and the Association of Official Agricultural Chemists. The definitions and standards adopted and amended since 1907 were this year revised and published as Service and Regulatory Announcements, Food and Drug No. 2.

During the year two meetings of the food standards committee were held, one in December, 1927, and the other in April, 1928. At the December meeting revised definitions for tea and for sage were adopted and subsequently

approved by the Secretary of Agriculture and published as Service and Regulatory Announcements, Food and Drug No. 2, Supplement No. 1. At this meeting also tentative definitions and standards for purified middlings, semolina, and farina, and for mayonnaise were drawn up. During the April meeting two public hearings were held, one for the criticism and discussion of the definition for mayonnaise and the other for similar consideration of the definitions for purified middlings, semolina, and farina. The committee at its April meeting finally adopted revised definitions for purified middlings, farina, and semolina, and for pasteurized cheese and for emulsified or process cheese, which met with the approval of the Secretary of Agriculture and were issued as Service and Regulatory Announcements, Food and Drug No. 2, Supplement No. 2. The definition and standard for mayonnaise is still under consideration. Products of corn, whole-wheat bread, and ice cream were discussed, with a view to future definite action.

CERTIFICATION OF COAL-TAR COLORS

The certification of coal-tar colors gives food manufacturers an opportunity to safeguard themselves against the inadvertent use of colors that might prove injurious to consumers. Batches of the permitted dyes—colors which chemical analyses and physiological tests have shown to be pure and harmless when properly prepared—are examined in the color certification laboratory and certificates are issued for those batches that meet the requirements set and are found to be pure and harmless. The requirements for the certification of coal-tar food colors and the procedure involved have been published in Service and Regulatory Announcements, Food and Drug No. 3. Table 2 shows the quantities of coal-tar dyes that have been certified during the last five years.

TABLE 2.—Coal-tar food colors certified, 1924 to 1928

Year	Straight dyes	Repacks	Mixtures	Batches	Number of firms	
					Total	New
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Number</i>		
1924.....	232,305.0	26,956.00	286,148.00	724	30	6
1925.....	315,848.0	39,013.79	284,060.00	883	34	9
1926.....	311,434.5	32,234.00	304,040.22	1,075	38	14
1927.....	277,044.0	28,844.13	374,804.28	1,172	52	10
1928.....	273,282.8	15,279.00	310,137.40	1,206	52	5

Thirteen batches of straight dyes and 23 batches of mixtures were rejected during the fiscal year 1927-28.

The falling off in total poundage of dyes certified is ascribed to the unseasonable weather during the spring of 1928, which curtailed the consumption of soft drinks.

In addition to its straight certification work, the color certification laboratory has brought to a successful conclusion several investigations undertaken to perfect its own methods and also to assist in the solution of various problems referred to it by the trade. Thus its investigation on the use of buffers, the results of which will be published in *Industrial and Engineering Chemistry*, has made possible a more correct determination of the color content of two of the permitted dyes—amaranth and ponceau 3 R—and the elimination of errors in the titration of mixtures of amaranth or ponceau 3 R with orange I.

To incorporate the results of recent investigations and the necessary information on the new dye, fast green F C F, and to meet certain criticism from the trade, the information on the chemistry and methods of analysis of the permitted coal-tar food dyes, issued in 1926 as Department Bulletin 1390, was revised.

FOOD-CONTROL INVESTIGATIONS

The main functions of the food-control laboratories are to acquire technical information that may be used as the basis of administrative action in the enforcement of the food and drugs act and in the technical review of cases developed by the field force, to assist the administration in making plans for proper enforcement of the act so far as it applies to foods, to improve and develop methods of analysis for the detection of adulterants in food, and to assist the field force in surveys and campaigns in connection with the enforcement of the act and in the examination of samples requiring the attention of specialists.

Among this year's activities the following may be mentioned. The use of heat instead of chemicals in preserving bottled cocoa-milk beverages was shown to be practical, and the beverage industry was informed of the results. A satisfactory steam-distillation method for the determination of certain essential oils dissolved in vegetable oils was developed. The chemical formula of a new vanillin substitute recently introduced from abroad

and sold under various trade names was determined. The work of acquiring analytical data on authentic fruit juices was continued. Twenty-six samples of honey were examined for heavy metals, mainly for the purpose of determining whether any commercial honeys were sufficiently contaminated with zinc to require regulatory action. An investigation of the effect of storage upon the composition of grape juice was begun.

Methods were worked out for the determination of hoof and horn in meat meal, for the determination of buttermilk in feeds, for the detection and approximate quantitative determination of rape oil in admixture with olive oil, for the detection and determination of citric and tartaric acids in processed cheese, and for the determination of citric acid in fruit products.

Surveys and investigations conducted in cooperation with the field forces included a survey of the blueberry industry in New Jersey and one of tomato-canning plants in New Jersey and Delaware, both in cooperation with the Philadelphia station. Of outstanding importance among such investigations was the fig work conducted by the western district, in which the food-control laboratories assisted, and the survey of the crab-meat industry in Maryland and Virginia, conducted jointly by the Baltimore station of the eastern district and food control.

DRUG-CONTROL INVESTIGATIONS

The drug-control laboratories study the various problems involved in the control of drugs and medicinal preparations, to the end that they may furnish the necessary assistance in developing cases under the act, improve and develop methods of analysis for the detection of adulterants, and assist the field force in surveys and campaigns and in examining samples that require the attention of specialists.

The examination of anesthetics was continued this year, with special attention to ether. As a result of these activities the quality of anesthetic ether is much improved. Applications for public-service patents on processes for the purification and preservation of ether worked out in the laboratory have been made.

The official bioassay standards specified in the United States Pharmacopœia, X, were distributed to firms and analysts in the United States and to official investigators in England,

Belgium, Poland, France, and Canada. Some 300 samples of drugs were assayed in the laboratory to determine whether or not they met the pharmacopoeial standards. The method for assaying mydriatics, developed in the laboratory, has been modified so that it can now be applied to mixtures of mydriatics and to several myotics. Because of the need for the standardization of glandular products, detailed studies were begun on the anterior lobe of the pituitary body, with a view to elaborating a method of assay.

The examination of products in the drug-control laboratories often results in new methods of analysis and new apparatus, and, now and then, in the development of new processes of manufacture. This year an improved apparatus for the determination of volatile oil was worked out, and methods for the examination of ginger and its preparations were devised. These are described in the *Journal of the American Pharmaceutical Association*. This journal contains also the description of a method for the estimation of acetylsalicylic acid (aspirin), phenylcinchoninic acid (cinchopen), and caffeine in admixture, of new methods for the determination of cinchopen and the choice of indicators for its titration, and notes on the quantity of alkaloids in hyoscyamus and a new method for its evaluation and on the constants of chloroform liniment, all embodying the results of investigations in the laboratories. Other research along these lines includes work on cocaine, microchemical methods for alkaloids, nitroglycerin, terpin hydrate, alcohol in drugs, chloroform and carbon tetrachloride, mercurials, arsenicals, apomorphine hydrochloride, the assay of sulphonal tablets, and chaulmoogra oil, all of which has been published in the *Journal of the Association of Official Agricultural Chemists*.

TEA ACT

The tea act, passed in 1897, is designed to prevent the importation into the United States of impure and unwholesome teas. The revised regulations for the enforcement of this law, with the text of the act, were issued during the year as Service and Regulatory Announcements, Tea No. 1. Each year the board of tea experts, appointed by the Secretary of Agriculture, prepares standards under the tea act by which tea shipped in may be judged. Those to be applied to tea shipped from abroad from May 1,

1928, to April 30, 1929, were published as Service and Regulatory Announcements, Tea No. 2.

Nearly 6,500,000 pounds less tea was imported during the fiscal year 1928 than during the fiscal year 1927. Of the 91,105,613 pounds offered for entry this year the tea examiners rejected 57,121 pounds, or 0.063 per cent, the smallest percentage of rejections since 1924. All of the rejections were for quality, no teas being rejected for purity. Many of the rejections were teas that had been damaged in transit and were consequently substandard in quality. The largest rejection, amounting to 11 per cent, was of Canton oolong teas, which are imported mainly for Chinese consumption. A large proportion of the 28,637 pounds of this variety of tea rejected had been entered as a crude drug, but the classification of the entry was changed and the tea rejected when it was determined that the shipments consisted entirely of low-grade tea. Out of the total amount of tea rejected by the tea examiners, only four rejections, amounting to 2,256 pounds, were protested by the importers. The board of tea appeals in each case sustained the findings of the examiner.

Although the total quantity of tea imported was less this year than last year, teas from Ceylon showed an increase of nearly 2,000,000 pounds, bringing the total importation of tea from this country for the past year up to more than 27,000,000 pounds. The importation of teas from India and Japan decreased more than 2,000,000 pounds each. The importation of green tea from China decreased more than 2,000,000 pounds and the importation of black tea from China more than 1,000,000 pounds. Teas from the Dutch East Indies showed a falling off of nearly 1,500,000 pounds.

For a long period of years the importation of black teas has shown a steady increase, that of green teas has decreased, and that of oolong teas has remained about the same. It is believed that this change to black teas is one cause for the decrease in the quantity of teas imported. Less black tea is necessary to meet the requirements of former green-tea drinkers, who still retain a preference for a light-colored beverage.

The percentage of teas examined at the field stations remained about the same as last year, the only noticeable difference being an increase in the examinations at San Francisco, due no doubt to the discontinuance of tea examinations at Chicago.

Tables 3 and 4 give the statistics on | just ended and for the three preceding
tea importations for the fiscal year | fiscal years.

TABLE 3.—*Tea examined from 1925 to 1928*

Kind, country, and station	1925	1926	1927	1928
Kind of tea examined:	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Green.....	27,684,016	27,161,377	29,134,337	25,505,836
Oolong.....	11,539,346	10,853,806	10,676,866	10,445,822
Black.....	53,702,108	60,536,631	57,784,376	55,153,955
Total.....	92,925,470	98,551,814	97,595,579	91,105,613
Country of production:				
Ceylon and India.....	42,737,909	44,666,759	46,170,976	45,879,440
China.....	10,243,393	13,697,341	12,793,519	10,138,371
Japan and Formosa.....	30,603,658	30,212,997	28,701,663	26,613,084
Dutch East Indies.....				
Java and Sumatra.....	9,331,230	9,949,767	9,923,539	8,473,689
Africa.....	9,267	24,950	5,882	1,029
Azores.....	13			
Total.....	92,925,470	98,551,814	97,595,579	91,105,613
Station examining:				
Boston.....	17,561,248	18,163,841	19,701,406	18,745,624
Chicago.....	2,691,550	3,299,810	2,306,941	
Honolulu.....	349,879	536,246	342,075	319,334
New York.....	49,540,734	54,410,223	53,074,737	50,082,291
Puget Sound.....	11,669,761	12,254,374	11,817,192	11,422,926
San Francisco.....	11,112,298	10,087,320	10,353,228	10,535,438
Total.....	92,925,470	98,551,814	97,595,579	91,105,613
Quantity exported from United States.....	1,817,245	675,745	743,217	517,998

¹ Nine months. Chicago discontinued April 1, 1927.

TABLE 4.—*Kinds and quantities of tea examined, passed, and rejected during the fiscal year ended June 30, 1928*

Variety and station where examined	Examined	Passed	Rejected
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Formosa oolong.....	9,704,905	9,704,330	575
Congou.....	1,543,653	1,542,712	941
India.....	17,537,023	17,531,286	5,737
Ceylon.....	27,029,970	27,019,602	10,368
Blended Ceylon and India.....	553,265	553,265	
Java.....	7,654,351	7,649,314	5,037
Sumatra.....	819,338	819,246	92
Ceylon green.....	381,480	380,245	1,235
Ping suey green.....	6,536,107	6,534,033	2,074
Country green.....	1,302,368	1,302,368	
Japan.....	15,305,858	15,305,453	405
Japan dust.....	1,602,321	1,600,321	2,000
Capers.....	490	490	
Scented orange pekoe.....	14,836	14,836	
Scented Canton.....	416,225	416,205	20
Canton oolong.....	249,140	220,503	28,637
Jasmine.....	75,552	75,552	
India green.....	377,702	377,702	
African tea.....	1,029	1,029	
Total.....	91,105,613	91,048,492	57,121
Station examining:			
Boston.....	18,745,624	18,740,541	5,083
Honolulu.....	319,334	319,034	300
Puget Sound.....	11,422,926	11,422,575	351
New York.....	50,082,291	50,053,728	28,563
San Francisco.....	10,535,438	10,512,614	22,824
Total.....	91,105,613	91,048,492	57,121

TEA-CONTAINER TESTS

It is a matter of common observation that a great many teas have been ruined by being improperly packed for distribution. To determine the value of various types of containers for the preservation of tea and to further guarantee to the consumer teas of quality, tests of more than 100 types and subtypes of containers have been conducted during the last three years. This series of tests, which has been carried on in cooperation with tea packers, container manufacturers, container manufacturers' associations, the Division of Simplified Practice of the Department of Commerce, and the Connecticut Agricultural Experiment Station, has just been completed, and the results are now being studied with a view to putting them in suitable form for use by the tea trade and allied trades.

IMPORT MILK ACT

The text of the Federal import milk act of February 15, 1927, which became effective on May 17, 1927, with the regulations for its enforcement, was printed as Service and Regulatory Announcements, Import Milk No. 1. This act provides that milk or cream shall be considered unfit for importation into the United States when all animals producing such products are not healthy, particular test being administered to insure freedom from tuberculosis; when the farms or premises on which the stock is produced or handled are not sanitary, as determined by a scoring system provided for that purpose; when the bacteria content exceeds certain announced limits; and when the temperature of such products at the time of importation exceeds 50° F. The act also provides that all importers or shippers must procure a permit before they are allowed to offer milk or cream for entry into the United States.

In the absence of an appropriation enabling inspection to determine that all of the provisions of the act had met with full compliance, the department granted temporary permits to shippers as authorized by the law. Shortly before January 1, 1928, Congress provided funds for active enforcement, and since that time the administration has maintained surveillance along the eastern section of the Canadian border, where the greatest volume of foreign milk or cream is offered for entry. A field station completely equipped with laboratory facilities was opened at Rouses Point, N. Y.,

and laboratory equipment was also placed at Richford and Newport, Vt. Inspectors, analysts, and veterinarians operating out of the Rouses Point station examine importations, draw and analyze samples, and make sure that the producing animals and premises are in compliance with the terms of the law.

It is contemplated to enlarge the laboratory facilities and personnel as time and funds permit. All temporary permits were withdrawn prior to July 1, 1928, except in the case of a very few shippers along the Mexican border where arrangements had not been perfected to make the necessary animal examinations and sanitary inspections at source. Those shippers who formerly imported under temporary permits were required to procure permanent permits. In all 675 permanent permits had been issued before the end of the fiscal year.

The enforcement of the import milk act has been greatly facilitated by the cooperation received from the Canadian Department of Agriculture. Authorized agents of that department have made the physical examinations and tests of animals and the sanitary inspections of barns and plants required by the law. As authorized by the act, the duly certified statements, signed by accredited Canadian officials and forwarded to this department, have been accepted in lieu of reports of examination and inspection made by our own agents.

INSECTICIDE ACT

The insecticide act of 1910 was passed to eliminate untruthful and misleading statements on insecticides and fungicides, including disinfectants. It makes illegal the shipment or sale within its jurisdiction of products that fall below the strength under which they are offered, that will not accomplish the results claimed for them, or that are injurious.

The work under the insecticide act has been continued along practically the same lines as those followed by the Insecticide and Fungicide Board, formerly charged with its enforcement. This work shows a steady growth each year, owing to the ever-increasing number of preparations designed for use against insect pests and fungus diseases. Not only are new preparations being offered for sale in large numbers but the formulas of many products put out under old, well-known trade names are being changed as

scientific knowledge advances and new ingredients are discovered. Apparently many of the new manufacturers of insecticides and fungicides do not maintain a close chemical control in their plants, nor do they always subject their preparations to thorough and accurate tests before placing them on the market. As it is most important that users of insecticides and fungicides be able to rely on these preparations to accomplish the results claimed for them, close surveillance by control officials is necessary.

Inspectors attached to the field stations make the necessary factory inspections and collect samples on which to base prosecution or seizure action

when necessary. The chemical and bacteriological work involved in the control of insecticides and fungicides is done in the laboratories at the stations and in Washington; the entomological tests necessary on insecticides are conducted at Vienna, Va., and Lake Alfred, Fla.; and the tests on fungicides are conducted at Haddon Heights, N. J., and Corvallis, Oreg. Both insecticides and fungicides are also tested at temporary quarters established at advantageous points as need arises.

The insecticides and fungicides sampled and examined under the insecticide act during the fiscal year just ended are listed in Table 5.

TABLE 5.—*Samples of insecticides and fungicides examined 1920-1928*

Product	1920	1921	1922	1923	1924	1925	1926	1927	1928
Arsenate of calcium and boll-weevil preparations	102	98	24	33	30	38	45	21	47
Arsenate of lead	51	79	77	80	33	19	54	24	67
Bordeaux mixture and combinations of Bordeaux mixture with insecticides	79	73	62	51	45	29	45	33	58
Chlorinated lime	6	22	10	10	3	3	8	8	13
Cyanide preparations						12	7	3	19
Dips for animals	20	26	49	69	26	22	30	34	66
Disinfectants, germicides, bactericides	83	102	154	174	99	161	137	132	175
Fly preparations for animals	33	30	36	59	25	30	32	30	36
Fish-oil and whale-oil preparations	9	6	9	10	13	6	6	6	1
Formaldehyde preparations	8	15	8	38	8	11	10	9	10
Insect preparations, household use	52	101	115	202	170	164	193	214	330
Miscellaneous insecticide and fungicide preparations, agricultural use	97	58	94	172	71	91	150	149	157
Lice and mite killers	32	57	61	58	91	102	83	80	125
Lime-sulphur solution and sulphur preparations	32	50	41	68	42	41	54	48	57
Nicotine preparations	6	7	31	34	22	25	22	17	19
Paris green	24	28	34	31	13	12	29	11	21
Pyrethrum and hellebore powders	43	17	60	92	72	42	29	58	45
Miscellaneous	40	51	92	55	61	56	58	74	131
Total	717	820	957	1,236	824	864	992	951	1,377

Of the 1,377 domestic samples collected, 420 were of new products never before sampled. As a result of the examination of these samples, 50 cases were reported to the solicitor for prosecution or seizure, 315 cases were satisfactorily adjusted by correspondence, and 72 cases were adjusted after the shipper had been cited to a hearing.

During the period covered by this report 311 import samples of insecticides and fungicides were examined. Of these, 87 were found adulterated or misbranded, calling for recommendations either that the shipments be refused entry until the labels had been corrected or that future shipments be detained. The other 224 lots examined were in compliance with the law.

CHEMICAL TESTS

Some of the chemical work on insecticides and fungicides, formerly done by the Insecticide and Fungicide Board in Washington, is now done in the field stations by analysts transferred from the Washington laboratories for that purpose. During this fiscal year some 1,600 samples of insecticides and fungicides were subjected to routine chemical analysis.

In addition special studies were made to develop improved methods of analysis, where the need for such methods was evident, and to ascertain the reason for certain types of violation of the law. Thus improved methods for the total fluorine and fluosilicate determinations have been

developed for use in examining fluosilicates, which have come into increased use in the past year.

Further work has also been done on oil emulsions, and official methods have been adopted by the Association of Official Agricultural Chemists on the basis of this work.

The study of the deterioration of nicotine soaps completed during the year shows that the deterioration in the case of drying-oil soaps is due to condensation of the nicotine with the fatty acids in the presence of oxygen. In the case of nondrying oils the deterioration is due to volatilization of the nicotine. Hence, deterioration can be prevented by packing in such a way that air is excluded.

Completed work on the optical properties of various compounds has been published in journal articles, entitled "The optical identification of the naphthalene sulfonic acids by means of their benzylpseudo-thiourea salts" and "The optical identification of alkaloids." Optical-crystallographic studies on ephedrine hydrochloride, ephedrine sulphate, pseudo-ephedrine hydrochloride, and pseudo-ephedrine sulphate, on various gossypol compounds, on ecgonine, and on aloin were also completed.

ENTOMOLOGICAL TESTS

Of 997 interstate samples received for examination, the efficacy claims for 767 were reported on, 230 being held pending further tests and chemical analyses. A special investigation of the insecticidal value of the oils and alkaloids of larkspur and stavesacre seeds has been completed and prepared for publication. Both the oils and the alkaloids were found to have insecticidal value. Work on the comparative efficiency of different samples of insect powder has clarified some of the factors governing such testing. The results are being prepared for publication. Studies looking toward the development of a method by which kerosene extracts of pyrethrum may be compared with products of standard strengths have been begun, that the large number of such preparations now sold may be satisfactorily tested. Paradichlorobenzene and naphthalene have often been recommended for use in ordinary living rooms to repel moths. Experimental work shows that they are not effective for such purposes.

FUNGICIDE TESTS

Besides determining the truth of the claims of fungicidal efficiency on the

labels of plant fungicides, a comprehensive series of experiments on several of the more important types of fungicides to obtain information necessary to pass on the labels of such products has been continued. Various dusts have been tested one against another and also against standard sprays. The serious injury caused by the use of colloidal copper was found to be much reduced by the use of lime. The addition of aluminum sulphate to lime-sulphur solution reduced injury and apparently helped the spreading of the spray. Dry sulphur-lime mixture was found to be satisfactory on apples under some conditions, but should not be recommended without limitations. Further data have been obtained on the applications for which Bordeaux mixture can be safely recommended for use on apples. In some cases sodium-sulphur compounds can be safely combined with lead arsenate, provided the arsenate is mixed with casein spreader before it is added to the sulphur compound. A special type of dusting sulphur gave control of anthracnose leaf spot of gooseberries where sulphur fungicides failed. This indicates the possibility of a much more efficient dust than is now in common use.

The use on certain varieties of cherries of Bordeaux mixture and other preparations previously thought safe for that purpose resulted in serious injury. Investigations are under way to determine the cause of this injury and how it may be prevented. Studies are also being made of the adhesive properties of various copper fungicides, both dusts and sprays. The organic mercury compounds which are used against seed and soil-borne diseases of plants have required special attention, as many of the labels and much of the literature bore claims that were too broad. While this work is not yet completed, a great improvement in the labels and literature of those products is already apparent.

VETERINARY TESTS

Labels have been reviewed and reports made on 289 samples of products offered for sale for use with livestock. Tests were made on 36 of the samples.

BACTERIOLOGICAL TESTS

One hundred and sixty-five domestic samples and 5 import samples of disinfectants were examined, as well as 190 samples of antiseptics for drug control.

In cooperation with drug control, an investigation of the germicidal activity of silver proteins was carried on. The results of this work have been incorporated in a paper which has been accepted for publication by the Journal of Laboratory and Clinical Medicine. The results of preliminary work on the resistance of various strains of streptococci are of significance in the testing of disinfectants and antiseptics. A comparison has been made of the results obtained by the Hygienic Laboratory method, the Rideal-Walker method, and a modified method of testing disinfectants, covering 25 samples of 5 types.

CAUSTIC POISON ACT

The Federal caustic poison act, which became effective March 4, 1927, places upon the department the responsibility of regulating interstate shipments and importations into the United States at its various ports of entry of certain dangerous caustic and corrosive substances and preparations containing them, and also the sale of such products in the Territories and the District of Columbia. The act requires that the products covered by it shall be labeled in a manner to convey knowledge of their dangerous character. It provides in general that these dangerous caustic and corrosive substances, when in containers suitable for household use, shall bear conspicuous and easily legible labels containing the common name of the substance, the name and place of business of the manufacturer, packer, seller, or distributor, and the word "Poison," as well as directions for treatment in the case of accidental personal injury.

The regulations for the enforcement of this act, with the text of the law, were issued as Service and Regulatory Announcements, Caustic Poison No. 1. This was followed by Service and Regulatory Announcements, Caustic Poison No. 2, giving a list of internal and external antidotes, which, in the light of present knowledge and information, are regarded as acceptable treatments in the case of accidental personal injury resulting from any of the substances covered by the act.

As soon as funds for the enforcement of the law became available the field stations started a survey of manufacturers of products coming within the jurisdiction of the law, with a view to bringing its provisions to their attention and initiating such action as might be necessary to see that its labeling

requirements were met. The reports from the survey show that many manufacturers had already taken cognizance of the law and had prepared or made the effort to prepare legal labels, and that for the most part the trade is in sympathy with the law.

One-hundred and sixty-two samples, most of them subject also to the insecticide act, have been examined for the presence of caustic poisons. Most of the preparations sampled were coal-tar dips and disinfectants, fly sprays, and bed-bug remedies, and contained phenol. The rest were principally lye and ammonia products.

Certain experimental work became necessary in connection with the control analyses. The method used for the determination of phenol, originated for use on saponified cresol solutions, was found to give faulty results on products such as bed-bug remedies, consisting of kerosene and phenol if they also contained methyl salicylate, frequently added to give the product a more pleasant odor. A modification of the method that permits of its use in such cases was developed however. Further, a study of the fractionation of mixtures of phenol with the various cresols showed that cresol which meets the distillation requirements of the United States Pharmacopeia, and liquor cresolis compositus, U. S. P., may contain enough phenol to bring these products within the purview of the law.

NAVAL STORES ACT

The naval stores act provides for the control of traffic in turpentine and rosin and also for the grading and classifying of these products by the Government, the expense of grading and classifying being borne by the producer or shipper requesting it. Furthermore, it makes provision for standards for naval stores.

ENFORCEMENT

In accordance with the general plan of the administration, the inspection and sampling of turpentine and of mineral-oil thinners sold as substitutes for turpentine were placed in the hands of the inspectors attached to the field stations on July 1, 1927. The samples collected were forwarded to Washington for examination.

During the year there have been examined under the regulatory features of the naval stores act 221 official samples of gum spirits of turpentine, 26 of steam-distilled wood turpentine, 3 of destructively distilled wood tur-

pentine, 13 of mineral-oil thinners, and 8 of sulphate wood turpentine. One sample of gum spirits of turpentine grossly adulterated with mineral oil and several labeled and invoiced in violation of the terms of the act were found. Steps are being taken to bring action against the shipper of the adulterated turpentine. The labeling and invoicing have been corrected in most instances through correspondence. Twenty investigational samples of turpentine and thinners were also examined for the purpose of obtaining information on the products sold by jobbers and the methods of handling them, or where the identity of a sample in the hands of a dealer could not be satisfactorily learned from the records. Sixty-three factory inspections were made at plants of distributors and jobbers of turpentine and mineral thinners coming within the jurisdiction of the act. Experimental work on a new method for detecting with certainty the presence of wood turpentine in gum spirits has been continued. Promising results have been obtained but additional work must be done to perfect the method.

Sixty lots of rosin, representing shipments of about 1,200 barrels, were sampled and graded at northern consuming points. Only a very few cases of misgrading were observed. One lot of rosin adulterated with dirt and trash was found. This appears to have arisen through careless handling at the still and in shipping out barrels of material that should have been redistilled. Prosecution has been recommended in the one instance noted of raising weights marked on rosin barrels for export shipment. In three instances the grade marks had been removed from barrels of rosin for export and higher grade marks substituted for them. Citation was recommended against the shipper of these goods.

SERVICE

During the year, under the service features of the act, 32 samples of turpentine were examined on request and 173,397 barrels of rosin were graded for producers at the stills in the South, and 1,162 barrels were graded at distributing points and consumers' plants in the North and East. This included practically all the rosin made in Louisiana, Mississippi, and Texas, and some in Alabama.

Total returns to the Treasury during the fiscal year amounted to \$12,369.69, of which about \$50 covered reimbursement to the Government for expenses incurred in connection with taking of

samples for analysis and grading on request.

Many consumers of rosin have expressed themselves as greatly benefited by the Government inspection of rosin, and producers also have voiced their satisfaction over the elimination of claims by purchasing consumers.

Those who wish inspections, gradings, or analyses under the service features of the act may communicate with the administration in Washington, D. C., or with the New York, Chicago, San Francisco, Boston, or Philadelphia stations, as may be most convenient. Rosin graders and classifiers are stationed at Washington, at the New York, Cincinnati, and Savannah stations, and also at Mobile, Ala., Gulfport, Miss., and De Ridder, La.

STANDARDS

In accordance with the naval stores act, a new standard for rosin having a decided red color, such as wood rosin, known as FF grade, was promulgated by the Secretary of Agriculture. The necessary colored glass for the standards for this grade has been ordered from the manufacturers in England.

Five complete sets of rosin standards were assembled and distributed. These were deposited at New Orleans, Cincinnati, Buffalo, and London and in the hands of a new State rosin inspector in Florida.

COLLABORATION WITH OTHER BRANCHES OF THE SERVICE

During the year the Food, Drug, and Insecticide Administration, as in the past, collaborated with several of the other branches of the Department of Agriculture and with other departments.

The greater part of this collaborative work was with the Post Office Department. The 50 postal cases handled called for numerous analyses, reports, hearings, and conferences. Of these cases, 32 were closed, either on fraud order or on affidavit. When a fraud order is issued, all mail is marked fraudulent and returned to the sender. Many firms, realizing that their business was illegal, voluntarily discontinued the use of the mails when they learned what was happening to others. Among the products which received fraud orders were an alleged consumption cure, consisting of turpentine gum, flavored with cinnamon; a "tuberculosis cure," made up of a number of worthless mixtures, marketed by one wholly ignorant of the disease; a so-called cure for can-

cer through the use in part of a bread and milk poultice; a "rupture cure;" and a height-increasing scheme. Sale of the following, among others, was discontinued on affidavit: A pernicious-anemia cure consisting largely of ground granite; two imported sirups similar in composition to New Orleans molasses, claiming to cure all ailments of the kidneys; an Epsom-salt diabetes cure; and a thyroid obesity remedy.

The Federal Penal Code, forbidding fraudulent transactions through the mails and working hand in hand with the mail-order fraud law, is enforced by the Department of Justice. Prosecutions are based on information furnished the Department of Justice by Post Office inspectors and specialists of the administration. A number of cases were taken into court. Some have been terminated; others are awaiting action. Three persons have been convicted and imprisoned.

Poisons in the mails have received their usual consideration. The Railway Mail Service has been advised on various problems. A number of products, mostly candies, supposedly containing poison, have been examined. One sample of candy contained corrosive sublimate; another strychnine. Morphine tablets were also intercepted.

Among the many samples examined for the Federal Trade Commission were soaps, cosmetics, "fat reducers," and "hair restorers." It was found that several of the toilet preparations were grossly misrepresented. So-called medicated gloves for softening and whitening the hands were the common 10-cent variety, unmedicated. A Federal court decided that a soap to be called naphtha must contain more than 1 per cent of naphtha when it reaches the consumer. On request of the commission an investigation was made to ascertain how much naphtha must be present in the soap when made, to comply with this decision.

During the year the usual analyses of foodstuffs purchased on contract for the Government were made. A large number of samples of foodstuffs were examined, chiefly for the Veterans' Bureau, General Supply Committee, Federal Trade Commission, and the Marine Corps.

For a great many years the various branches of the Government have been utilizing the services of the tea experts of the Department of Agriculture in the purchase of teas. Through the efforts of the tea-control laboratory, practically all of the departments and independent establishments of the

Government that buy teas, including the Navy Department, Marine Corps, Veterans' Bureau, and Department of Justice, have established physical standards that are set up once a year for the purchase of their teas. This system is a great improvement over the one formerly used for the purchase of teas by the Government, as it standardizes the kinds and qualities used in each department and is more satisfactory to both the bidders and the Government. It is believed that it is also more economical. This establishment of standards for commodities bought by the Government has been extended to the purchase of coffee, the Veterans' Bureau having recently set up a physical standard for the purchase of coffees. These coffees are passed upon by the tea-control laboratory, in cooperation with the food-control laboratory, organoleptic tests being employed in making the comparisons.

Sixty-six samples of insecticides and 28 samples of disinfectants were examined for other branches of the service.

COOPERATION WITH STATE AND CITY OFFICIALS

The chemist in charge of cooperation has visited most of the State food and drug officials at their headquarters and has also attended all meetings of these officials, including the annual conference of the Association of Dairy, Food, and Drug Officials of the United States and the annual meeting of the American Public Health Association.

There is no evidence of any lack of interest on the part of State and city officials throughout the country in maintaining the cooperation which has been in effect for the past 15 years. On the contrary, there have been evidences of further constructive efforts on the part of cooperating officials to amalgamate more closely their common interests. In November, 1927, there was formed the Ohio Valley Association, made up of food, drug, and health officials in State and city offices in the territory surrounding Cincinnati. This association meets in Cincinnati once every three months for the informal discussion of projects under actual consideration by the member officials. This informal conference is modeled after the one that has been held bimonthly in Philadelphia for several years.

The reports from the districts and field stations are equally encouraging,

uniformly crediting the State and city officials with whole-hearted response to the frequent requests for assistance in connection with Federal projects designed to control commerce in foods and drugs.

PUBLICATIONS ISSUED

In addition to the 8 service and regulatory announcements, and 1 supplement to these announcements, mentioned elsewhere in this report, there were issued during the fiscal year just

ended 500 notices of judgment, and an index to Notices of Judgment 14001 to 15000. Technical Bulletin 64, Bacteriology and Chemistry of Oysters with Special Reference to Regulatory Control of Production, Handling, and Shipment, and a revised edition of Department Bulletin 1390, Chemistry and Analysis of the Permitted Coal-Tar Food Dyes, were also printed. Members of the staff contributed an article to the Journal of Agricultural Research and 73 reports and articles to scientific and trade journals.



JFC 14 1928

EXPERIMENT STATION FILE
REPORT OF THE FORESTER

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., September 1, 1928.

SIR: I have the honor to transmit herewith the report of the Forest Service for the fiscal year ended June 30, 1928.

Respectfully,

ROBERT Y. STUART,
Forester.

Hon. W. M. JARDINE,
Secretary of Agriculture.

FOREWORD

Most of the fiscal year covered by this report falls within the term of office of my predecessor, William B. Greeley, whose resignation took effect May 1. He was in charge of the Forest Service for eight years and a member of it continuously, except for military service during the World War, from 1904. At a material personal sacrifice he gave the forestry movement throughout the country leadership of an outstanding character, and the gains made during the year were largely a fruition of that leadership.

THE TWO PRIMARY TASKS OF THE FOREST SERVICE

The work of the Forest Service divides into two primary tasks—national forest administration, and promotion of the best use of all forests and forest products throughout the United States. In eventual importance to the public welfare the second named ranks first; for the national forests contain less than one-fifth of the forest land in the country, and their capacity to grow timber is scarcely more than one-tenth of what all our forest land might produce under skillful management. In expenditures, however, the national-forest work has the lion's share. Details regarding the character and purpose of these expenditures will be found on page 59. The expenditures for all purposes totaled \$22,657,454.83, of which those designed to further State and private forestry and to promote the best use of all

forests and forest products throughout the United States made up \$2,166,706.65.

OUTSTANDING FEDERAL LEGISLATION OF THE YEAR

From the standpoint of the national interest in more and better forestry, a notable development took place last year. This was the passage by Congress of two measures which may fairly be hailed as, together, of epoch-making importance—the so-called McSweeney-McNary law, laying down, through specific authorizations for a 10-year period, a financial program for the expansion of forest research, and the so-called McNary-Woodruff law, laying down a similar program for enlarged purchases of land for national-forest purposes during the fiscal years 1929-1931, inclusive. The relationship of the second law to the general forestry situation will be shown a little later. It is true that these acts become effective only to the extent that Congress actually makes the appropriations which they merely authorize; but both measures were reported upon by the Bureau of the Budget as not inconsistent with the financial policy of the administration, and their enactment gives a considerable assurance that their essential purposes will be attained. These laws will unquestionably accelerate the forestry movement throughout the country.

BETTER KNOWLEDGE ESSENTIAL

The ultimate goal of the forestry movement is the best use of all forest lands in the United States. As long

ago as the early seventies of the last century there was widespread uneasiness over the rapid rate of forest destruction. To this period belong the Federal timber culture act, a considerable number of State laws designed to encourage forest planting through bounties, tax exemptions, and like measures, a certain amount of equally futile forest-fire legislation, efforts of railroad companies and others to introduce extensive timber growing in the prairie and plains region, and so on. In 1877 the Secretary of the Interior urged that the policy of disposal of the public domain timberlands should be replaced by a policy of retention of the land, sale of mature timber at its market value, the reservation and protection of young growth, and provision for securing reforestation of cut-over areas—in other words, virtually the present national-forest policy applied to a much greater forest area. Even so we would not now be on a par with Canada, which has and will retain in public ownership over 90 per cent of its forests; but we would be much nearer that position. The proposal, however, was premature. The law would not have stood, had it been passed. The fundamental need was for more knowledge—better knowledge as to what a sound public policy really made requisite, knowledge as to how to make it work successfully, and public understanding of the issues involved.

In 1873 a committee created by the American Association for the Advancement of Science addressed a memorial to Congress asking for the creation of a Federal "commission of forestry," the duties of which would be to ascertain (1) the amount and distribution of woodlands in the United States, the rate of consumption and waste, and the measures requisite to assure adequate future timber; (2) the influence of forests upon climatic conditions, especially those necessary for successful agriculture; (3) the methods of forestry as developed and practiced in Europe. Eventually Congress made a partial response to these recommendations by appropriating, in 1876, \$2,000 for the employment by the Commissioner of Agriculture of "some man of proved attainments" to "prosecute investigations and inquiries" along the lines proposed. The published reports of the old Division of Forestry show how decade after decade, with the most meager provision of resources for the purpose, the economic facts basic for the determination of sound public policies were striven for.

Nevertheless, many false suppositions remained long current. Even now we do not fully know "the true condition and wants of the country"; still less do we know in full the measures requisite to assure adequate future timber supplies. It was in recognition of this fact that Congress enacted last May the McSweeney-McNary Law—the first entirely comprehensive provision for forest research ever made in this country. The work for which \$2,000 was appropriated in 1876 and which has been going on ever since, at first as a one-man job, and with expenditures to the very end of the nineteenth century never as much as \$30,000 annually, now receives a Federal authorization up to a maximum of \$3,375,000 annually within the next 10 years, a further authorization of \$3,000,000 available at the rate of \$250,000 a year, and beyond 1938 such annual appropriations as may thereafter be necessary to carry out the law.

WHERE WE NOW STAND

The forest problem concerns the most economical and advantageous use of one-fourth of the land surface of the continental United States—to say nothing of Alaska, our insular possessions, or our interest in the possible contributions to American requirements of the tropical forests south of us. It concerns the best use of this huge land surface not only for the production of wood—important as that is to our economic well-being—but also for meeting other and varied public needs. Especially does it concern the regimen of water flow from our natural forest regions.

It concerns also the auxiliary use of a large part of this vast land area for livestock production; its relationship with agriculture, mining, and other land uses; its production of game, fish, fur bearers, and other forms of wild life; and its public value for recreational purposes. The difference between right use of it all in the best interest of the general welfare and unintelligent use is crucial. A great national interest is involved.

THE EASTERN PROBLEM

In some quarters the impression is gaining ground that our forest problem has in the main been solved, or will work itself out. A great further public effort must be made. In chief part it must be made in the East. In very large part it must be made by States and local communities in the

East. The eastern half of the so-called continental United States—that is, exclusive of Alaska—contains three-fourths of the forest land, six-sevenths of the population, and five-sixths of the land in harvested crops; but less than two-fifths of the standing saw timber.

Less than one-sixth of its forests are virgin, and it is now drawing upon the virgin stands of the West for more than one-fifth of its annual consumption of lumber. Cut-over forests, varying in present condition from second growth ripe for the saw to land wholly denuded of valuable timber and incapable of again producing valuable timber without expensive regenerating measures or an indefinitely long delay, make up all but a relatively small and fast-diminishing portion of the eastern total forest area; and of the total more than nineteen-twentieths is privately owned. That, in a nutshell, indicates where lies the country's main forest problem of today. What is to be the future of this enormous private forest land area east of the great Central Plains?

The West is an entirely different situation. Of its forest land, three-fourths is in public ownership, and the future of this land is virtually assured. It will nearly all remain publicly owned and continuously productive. The Federal Government alone owns more than 70 per cent of the forest land in the West, while States and municipalities own 3 per cent. In the East, on the other hand, the Federal Government owns less than 2 per cent and States and municipalities less than 3 per cent. The West, therefore, is in a position much more nearly approximating that of Canada, where, as already noted, over 90 per cent of the forest land is publicly owned, while the East is in a position without parallel in any civilized country of at all comparable conditions.

The British Isles, it is true, show an even higher percentage of private forest land ownership than the eastern United States; but less than 5 per cent of Great Britain and Ireland is in forest. The United Kingdom has in consequence become almost entirely dependent upon other countries for its requirements of lumber, mine props, pulp and paper, and other forest products, while at the same time it fails to utilize fully the capacity of its land to grow needed timber crops and to give labor employment. Incidentally, since the war afforestation has been recognized in Great Britain as of large importance to the nation.

The United States can not afford to let things drift, to wait passively for economic forces to work out the problem in their slow way. In time those forces alone would largely accomplish what needs to be done. Gradually private landowners will come to grow timber crops on a larger and larger part of the 336,000,000 acres of eastern forest land which they now own. Gradually they will abandon a larger and larger part of the land which they can not make pay enough to meet its tax bills; and gradually forced public ownership of these abandoned and wrecked lands, brought about through a process of automatic land classification, will lead to policies of public administration and reclamation expenditures. Gradually the public and private burdens imposed by maluse, both in the form of shortages of necessary forest products and in the form of impoverished localities, stripped mountains, man-made deserts, and violent changes in the character of stream flow, will sternly bring home the necessity for finding remedies. But the cost of waiting for all this and the easily preventable deterioration in the ability of the forest to respond to right practices make the suggestion of such a course monstrous.

Already conditions have been created in parts of the country which leave it doubtful whether some of the land has not passed over from the class of potentially useful into the class of permanent though artificial desert. It may be past the point at which it will even repay public reclamation. To let this conversion go on is a crime against posterity. It is also an impairment of present values such as we can not ourselves afford.

THE FOREST LAND PROBLEM IN THE WEST

A situation which has arisen in Idaho during the year illustrates the danger. The Idaho law requires all forest-land owners to maintain adequate protection against fire. If they fail to do so the State supplies it and charges the cost to the owners as a tax. The timberland owners have organized protective associations, with which the State cooperates. These associations maintain protective systems, each covering a certain territory. In proportion to its own forest-land holdings within the territory, the State contributes toward maintaining the system; and it constitutes the associations its agency for protecting lands whose owners do not voluntarily take on the task.

Climatic conditions make the cost of protection high. In north Idaho the associations contract with some small owners to provide protection on the basis of 6 cents per acre per year, and at that do not nearly reimburse themselves. For the sake of their own timber holdings, however, they must cover all the land.

This system is threatened with disintegration. As company holdings are progressively cut over the inducement to pay the cost of protection grows less and less, for the interest of most owners is chiefly if not wholly in the merchantable stand. The alternative to paying the cost of protection on cut-over lands is tax delinquency; and that is rapidly developing.

As already noted, the protective associations can not limit themselves to selected lands. Fires show no respect for section or township boundaries. Consequently lands on which taxes are uncollectible can ride free. When they do, they increase the bills for those who still pay.

Unappropriated and unreserved lands of the United States have been riding nearly free. Tax-reverting lands ride free because they pass not to the State, which cooperates with the associations, but to the counties, which do not cooperate and do not see how they can afford to cooperate. Consequently the lands which should be a permanent asset to the counties through continuous timber production are being converted into a permanent liability through loss of the young growth left after logging. Most of the land, especially in north Idaho, is not worth its carrying cost for grazing use alone; and aside from timber growing and grazing it has no use, either present or prospective.

This has resulted in a strong local demand for a law to extend materially the St. Joe and Coeur d'Alene National Forests. The object sought is twofold: To obtain adequate protection of the widely scattered areas of unreserved public lands that would be thrown into the forest through establishing new boundaries, and to make possible the acquisition by the Government of private cut-over lands under the provisions of the general exchange law.

The underlying economic factors involved are clear, and they will be operative ultimately far and wide throughout the West, as they are already operative in certain parts of the Lake States and in other regions of the East. Private ownership of extensive areas of western timber-

lands has been undertaken in order to obtain the timber. That gone, much of the land will come back on the public. Originally a part of the public domain, through tax reversion it is forced out on the State or county. To restore it to productive condition is a long and burdensome undertaking, which neither the States nor the counties as a rule want to assume. The public welfare requires that it be assumed, and in many cases national-forest administration affords a means for accomplishing it. Under these circumstances the local anxiety that has sometimes been manifested for having the valuable national-forest timberlands opened to private acquisition or made over to the States is replaced by a pronounced anxiety to have the forests made larger.

The Idaho example suggests important questions of future public policy in handling national-forest land and timber exchanges, and of relations with the Western States. They are to some extent outlined in the section of this report entitled "The national forest properties." They suggest also that the Western States have some large problems of their own in connection with the permanent use of their forest lands which will have to be worked out in other ways than through the national forests alone, important as is their part.

PROGRESS IN PUBLIC FOREST OWNERSHIP

Land purchases by the Federal Government for forest purposes began in 1911, when the Weeks law provided for the purchase of lands necessary to regulate the flow of navigable streams. The Clarke-McNary law, passed in 1924, formulated a larger Federal policy of forest-land acquisition. It authorized and directed the Secretary of Agriculture to recommend for purchase also such lands as in his judgment are necessary for the production of timber. All recommendations of purchase for either purpose are made to the National Forest Reservation Commission, as the approving authority. The McNary-Woodruff law, passed last April, supplements the earlier laws by setting up a definite program of expenditures for both purposes together. For the fiscal year 1929, \$2,000,000 was authorized; for 1930, \$3,000,000; and for 1931, \$3,000,000.

As originally framed the McNary-Woodruff law had in view an authorization of appropriations to a total of \$40,000,000, over an 8-year period,

beginning with 1928. This program, however, was found by the Bureau of the Budget not to be in accord with the financial policy of the administration. The program was therefore curtailed to that already indicated. The agricultural appropriation act carried a \$1,000,000 acquisition item for the fiscal year 1929, and the second deficiency act added \$1,000,000 more, which, however, was pledged beforehand for expenditure to acquire the so-called Waterville tract in the White Mountains of New Hampshire—a special case of which more will be said later. The main thing to be noted in connection with the McNary-Woodruff law is that it authorizes the undertaking in the fiscal years 1930 and 1931, if Congress makes the necessary appropriations, of a purchase program markedly larger than that of the past.

The enlarged program had its origin in the inquiry into the forest situation throughout the country made in 1923 by the Senate Select Committee on Reforestation. The hearings held by that committee in the various forest regions of the United States disclosed that vast areas of forest land were in danger of lapsing into unproductiveness, that where new timber growth has followed utilization of the original stand it is in large part a relatively poor growth—a wild-land natural crop produced in the face of many adverse circumstances of man's making—and that the future timber needs of the country are not being adequately provided for. The Weeks law program had taken no account of the needs for reforestation of more than a very small part of the forest lands of the eastern United States and was entirely inadequate to meet public requirements even for stream-flow protection.

The 1927 Mississippi floods brought forcibly home the inadequacy. Not that forests alone could have controlled those floods; their function is auxiliary. Following the 1927 disaster the Forest Service undertook a comprehensive survey of forest conditions over the entire Mississippi Basin as related to flood prevention. The results were presented to the Committee on Flood Control of the House of Representatives in a special report, which has since been published under the title "The Protection Forests of the Mississippi Valley Watershed and Their Part in Flood Prevention." The report made clear at the outset that forestry should not be thought of as an alternative to artificial works of control; but it showed that the need

for forestry to supplement such works is both real and extensive.

Very briefly, the study brought out that of the more than 1,230,000 square miles in the Mississippi Basin 289,000 square miles, in round numbers, are embraced in what may be termed "critical areas"—that is, areas on which the vegetative cover exercises such an influence on the character of the run-off or on soil erosion as to be important from the standpoint of flood control. These critical areas embrace about 150,000 square miles of forest land out of a total of about 244,000 square miles of forest land in the entire basin. While forest land now constitutes only one-fifth of the entire area of the basin and never constituted more than about two-fifths, the consequence of serious impairment of the capacity of the forest to retard run-off and prevent erosion on the critical areas makes necessary public action both to conserve forest values on portions of these areas where the present conditions are beneficial and to restore forest values where the present conditions are detrimental or neutral.

About 35,000 square miles of forest land in the basin has been so denuded of valuable forest or other growth as to fall into the class of "idle" or "waste" land. Farm woodlands comprise about 115,000 square miles, or 47 per cent, of the entire forest-land area and include about 10,000 square miles of "idle" or "waste" land. State and Federal forests and parks contain, respectively, 700 and 43,000 square miles, or 18 per cent of the forest land. The only forest lands on critical areas that are now contributing full service from the standpoint of flood control are those embraced in public forests and parks; and a substantial increase of public forest-land ownership and administration will be essential to the adequate regulation of stream flow on the headwaters of the Mississippi and its principal tributaries.

The same is true elsewhere. Altogether there are unquestionably scores of millions of acres in the East that are subject to harmful erosion and seriously accelerated stream flow discharge through impairment of the forest cover, and to a degree which will presumably necessitate much more extensive public-forest ownership than even the present national program contemplates.

That is not a task for the Federal Government solely. To a large extent

it should be a State function. Often local public welfare is chiefly involved; nearly always it is largely involved. Some of the Eastern States are assuming substantial responsibilities for the maintenance of forest conditions through land acquisition. New York's "forest preserve" includes more than 2,000,000 acres of State-owned land in the Adirondack and Catskill regions; Pennsylvania has under management nearly 1,300,000 acres of her forest-covered mountain ranges; and both States are adding to their holdings. Protection forests—which may also be made heavily timber producing, as Pennsylvania is making hers; which if carefully bought and skillfully managed should commonly prove a source of net revenue; and which always can be made to render other important public services as recreational areas, protectors of scenic values, and producers of game and other wild life—should receive the consideration of almost every State east of the plains.

What is called for immediately is a more intensive study than has hitherto been made of the extent and character of the need in this field. The survey of forest conditions throughout the country necessary as a part of the still more general survey contemplated by section 9 of the McSweeney-McNary law will, if the authorization therein conveyed is made effective through appropriations to finance the work, afford essential data for working out a comprehensive policy, with due correlation of Federal and local responsibilities in a unified plan of action. Meanwhile the act of May 15, 1928, "for the control of floods on the Mississippi River and its tributaries," has directed that the President shall "proceed to ascertain through the Secretary of Agriculture and such other agencies as he may deem proper the extent to and the measure in which the floods in the Mississippi Valley may be controlled by proper forestry practice," and on June 1, the President requested the Secretary of Agriculture to ascertain and report to him regarding this matter. Accordingly such additional studies of the relationship between proper forestry practice and flood control will be made as are possible with the present appropriations.

THE STIMULATION OF PRIVATE FORESTRY

One of the most significant developments of the past few years, as pre-

vious reports have brought out, has been a changing attitude of large timberland owners and of the lumber and other forest-using industries toward forestry. Timber growing is no longer regarded as something outside the range of business consideration. Instead there is a widespread open-mindedness and a general acceptance of the fact that it will have to be undertaken. But private land management for this purpose must at best come gradually. It calls for skill in applying the right woods practices; for going industrial enterprises it calls as a rule for a large readjustment, if not a radical making over, of financial structure and operating plans; and beyond that it calls for favorable conditions. The landowner will apply conservative woods practices (assuming that he knows what they are) only if and where he believes they will pay. No forester would undertake to advise a landowner that timber growing would constitute in his case a sound investment without first ascertaining whether the specific conditions are favorable. Very commonly they are not.

Favorable conditions include the factors which determine the yield that can be obtained—such as the present condition of the forest, the character of its soils, and the degree to which regional and local climatic conditions make for rapid growth. They include also the factors which determine the outlay necessary to obtain a given output—such as initial investment in land and timber, carrying charges, logging and manufacturing costs, and nearness to markets or transportation costs. And, finally, they include the market itself—that is, the price which can be expected for what is produced. Private forest management is going to come first where the economic conditions are most favorable—where the prospects of success in the new business venture involved are least dubious. It will be selective, progressive, but gradual in its advance. That is one reason why, no matter how fast it extends (within the limits of the possible), it can not at best extend either fast enough or far enough to afford by itself a solution of the eastern forest problem. But it is important not to block its extension. On the contrary, a large part of the public effort must be directed toward making the conditions more favorable.

The urgent importance of doing this is obvious; for what is at stake is the efficient economic use and continuous

productiveness of the 336,000,000 acres of privately owned forest land in the East; of five-eighths the surface of New England, more than two-fifths of the Lake States, two-fifths of the mid-Atlantic States, and three-eighths of the South Atlantic and Gulf States. While here and there some small parts of this vast land surface give promise of being maintained under forest management, there is no assurance as to the future of the great bulk of it.

The things necessary to hasten the private application of forestry to as much of this land as possible are fairly well recognized: Security against excessive taxation, efficient systems of protection against fire, public research and demonstration of usable practices, and consistent, steady educational effort to win the acceptance of such practices. The danger that taxes may absorb all, if not more than all, that forest owners might be able to make through investing in management is by itself in many cases of determining weight. The tax question is one of great complexity. In various ways a number of States have tried to apply a solution. The most hopeful element in the situation at present is the extent to which the question is being grappled with. As for fires, the problem is simpler. It is essentially to develop more widespread public interest and greater financial support. For research, the authorizations carried by the McSweeney law propose a program which if put into effect through corresponding actual appropriations will increasingly make available the kind of knowledge that the private owner needs in order to practice forestry. And the enlarged program of national-forest acquisition which the \$8,000,000 authorization of the McNary-Woodruff law inaugurated will greatly augment the opportunities for demonstration. If the States keep pace with similar policies, the public program required to accelerate the spread of private forestry will be well rounded out.

FOREST-FIRE CONTROL BASIC

The beginning of forestry is fire control. Until fire is systematically kept out of the woods all attempts at permanent use of the land for timber growing must be abortive. It is impossible to establish reasonably full new stands in the face of even light periodic fires. Irrespective of who will eventually own forest lands, the first essential is to keep them from being reduced to worthlessness by fire. This is now generally recognized.

While the provision made to keep out fires from the forests of the East is still barely more than half of what is necessary for adequate protection, every Eastern State but one with considerable forests within its borders has initiated action.

In this field the thing to do, of course, is to carry to conclusion what has already been begun. That calls for a very material strengthening and extension of the established State systems of protection. These are maintained through cooperative Federal, State, and private expenditures. Widespread assent has seemed to be given the theory that a fair division of the burden of protection would be accomplished if the protected property paid one-half the cost, the Nation one-fourth, and the States one-fourth. The estimated total requirement for the East (exclusive of lands Federally owned) is about \$8,400,000. The expenditures last year were about \$2,400,000. Of this the States paid nearly \$1,700,000, the Federal Government less than \$800,000, and private owners less than \$200,000.

The Clarke-McNary law, passed in 1924, authorized an annual Federal appropriation for this work throughout the country of \$2,500,000. The appropriations actually made hitherto, however, have been far below the authorization. The largest is the one for the current fiscal year. Its amount is \$1,200,000. In comparison with the States, the Federal Government is not yet taking its proportionate share of the load.

THE PRIVATE OWNER'S PART IN PROTECTION

The greatest deficiency, however, in the East is in the share taken by the private owner, if the 2-1-1 ratio is anywhere near right. Eastern private forest owners are doing far less than western owners to protect their lands from forest fires. This is doubtless primarily because of the lower property risk involved. Cut-over lands, of course, have no such cash values exposed to destruction as virgin forests present; and western climatic as well as forest conditions make the average exposure there particularly severe. Eastern forest fires as a rule have their most serious effect in the destruction of young growth and the loss of soil value; they are more important from the standpoint of the future forest than from that of the present stand. Nevertheless, it is not without significance that private, State, and

Federal funds expended for the maintenance of organized protection systems outside the national forests have in the West the ratio of approximately 7-2-1; in the East, of approximately 2-10-3. Or, to state it in another way, western timberland owners put up last year toward the cost of fire protection under State authority \$7 for every \$3 disbursed by the State and Federal Governments combined, while eastern owners put up \$2 for every \$13 from the other two agencies.

Two possible ways are open to reduce or eliminate this deficiency—inducement and requirement. In the West the method of requirement has been developed. Timberland owners in the State of Washington, for example, who do not voluntarily contribute on an acreage basis to the protective associations have the cost of protection levied against their holdings by the State, as part of their taxes.

Obviously, in regions where the present tax burden is producing or threatens to produce extensive abandonment of title, a required contribution toward the cost of protection would tend to increase abandonment. The application of such requirements in the East should, it is believed, take place only as part of a comprehensive State policy of forestry, with the State prepared to take over the land if the private owner is unwilling to retain and partly meet the cost of protecting it and can not dispose of it to some one else who will. Lands thus taken over by the State should, of course, be given protection by the State itself and should, as rapidly as practicable, be built up into units suitable for permanent forest administration. This would require provision (1) that all forest lands becoming tax delinquent are, after a reasonable time, to be taken over by the State for forest purposes; (2) that an administrative agency of the State is to create consolidated holdings through further land acquisitions, where this is necessary, by purchase or exchange, lands taken over to be available for the latter purpose; and (3) that such consolidated holdings are to be thereafter administered as permanent State forests, under competent technical management.

Such a course if generally adopted in the East would have some obvious advantages. Not only would it tend to enlarge materially the now wholly insignificant proportion of the forests in public ownership, it should tend also to increase the interest of private

owners who hold and protect their land in the further application of forestry.

FOREST MANAGEMENT THE GOAL

Fire protection, of course, is not in itself the practice of forestry; it is merely the preliminary, though essential, first step, to give the forest a chance to live and perpetuate itself. Beyond that comes actual management. The cases in which private owners have as yet inaugurated forest management are, it must be admitted, relatively infrequent. But the precise acreage of lands under bona fide, systematic forest management is at the present time less important than which way the land is headed. Is it headed toward further depletion and eventual discarding, like a sucked orange, by its owner? Or is it headed toward permanent use for timber growing? Land whose owner has begun voluntarily to put money into conserving forest values is headed the right way. If requiring protection would substantially increase the amount of such land, it would to that extent improve the outlook.

Right use, however, can not be brought about by fiat. It is a matter quite as complex, difficult, and progressive as bringing about efficient agriculture. In fact, it is closely interwoven with the problem of the best use of our land for agricultural production. Forestry and agriculture are complementary and sometimes competing forms of land use. They have much in common. In considerable measure timber growing will take place as a part of diversified agriculture, on farms. In regions like the South it calls, along with other things, for a large change in the conceptions and practices of the rural population relative to land use—the substitution for current and traditional methods of a more scientific, modernized agriculture; the remodeling of an out-of-date adjustment of those who make use of the soil to the resource by which they live; in a word, rural progress. It calls everywhere for a revolutionary change in the attitude of the great lumber industry toward its source of supply of raw material—a revolution fortunately already on the way. It calls alike for a truly tremendous undertaking in public education to bring about the introduction of right practices and for an equally formidable undertaking to find out what, under the most diverse regional and local conditions, the right and workable practices are.

WHAT NEEDS TO BE DONE

The salient facts regarding the forest problem of the country indicate on their face the main features of the public program that should be pursued. It should give full recognition to the conditions in the eastern half of the country, where by far the acutest phase of the problem is found and where almost all the forest land is privately owned. There plainly two major purposes need to be pursued. One of them is to hasten the economic process by which, in time, probably the major fraction of the present private forest land in the eastern half of the country—and for that matter in the West, too—will come to be used for timber growing by its owners, as a paying private enterprise. The other is to adopt public policies of forest-land acquisition and administration on a scale that will bring the East, without too long delay, into a situation more nearly comparable with that of the West and of every great nation of the civilized world having extensive forest resources.

In every part of the country it is important to check the forest deterioration caused by fire. The public protective systems now provided in nearly all the States having substantial forest areas must be made equal to this task. Almost nowhere are they as yet adequately supported, and in many States they are no more than introduced. Unless the 2-1-1 ratio of cost apportionment to the landowners, the State, and the Nation is to be discarded, the Nation must pay substantially more relatively to the States, and in the East private owners must as a rule pay much more, relatively to both. In some of the Southern States, however, private owners are now contributing more than the Federal Government and the State together.

But merely stopping forest fires is not enough. To become fully productive, forests must be skillfully managed, not merely held as wild lands. Timber-growing as a form of land management for private owners in the eastern United States can hardly be said as yet to have attained the status of even an infantry industry. A large part of the public effort in connection with forestry must be directed toward finding out the how and where of private forestry, and getting the results into practical use—toward research and industrial education. That is in itself a very large task. Fortunately, the new McSweeney-McNary law au-

thorizations give promise that it will be prosecuted with the vigor that its importance calls for.

This, however, is still not enough. At best, private forestry is going to advance only a step at a time, beginning where the conditions are most favorable. It will very gradually edge up on the core of the problem from one side; and it will never accomplish more than a partial solution. Public forestry must attack the core from the other side through State, Federal, and municipal forest acquisition, aimed primarily at obtaining (1) the land most necessary from the standpoint of watershed protection, recreation, and like public needs, (2) land which, under management, will tend most effectively to stimulate private interest in timber growing, and (3) land necessitating such outlays for its reclamation to good timber-growing conditions that not for a long time, if ever, will private capital make use of it.

A further question that must be faced is that of public policy respecting the land in the enormous twilight zone between the very few million acres which on the most optimistic estimate can be classed as now under private forest management and the few million more now under public administration, pending the time when it will be reached from one or the other side, in the course of decades, under the process outlined above. The application of management by private owners is in the nature of the case something that must come about as a voluntary choice on their part, if it comes about at all; the public has no power to compel it. On the other hand, the States unquestionably have it in their power to place on timberland owners at least a part of the cost of maintaining a general system of fire protection, for in some States this is now being done. Where States are prepared to take over tax-reverting lands and build them up into publicly managed forests, requiring private owners to contribute toward the cost of protecting their lands would presumably accelerate the reduction of the twilight zone from both sides. It would also prevent the deterioration which fire causes without compelling the public to bear the entire expense where the private owner wants to play a waiting game, holding off from expenditures until he can see whether it will pay best to hold the land permanently or to abandon it—a game for him of heads I win and tails you lose.

WHAT IS BEING DONE

The Federal Government has been cooperating with the States for 17 years in the prevention and suppression of forest fires, largely to stimulate and make profitable the growing of timber by private owners. The Weeks law of March 1, 1911, was the first Federal-aid law embodying the 50-50 principle of cooperation. It provided for protecting from fire the forested watersheds of navigable streams, in cooperation with any State that would spend in the same year an amount at least equal to the Federal expenditure. Fire protection is the activity around which Federal and State cooperation in forestry has developed. A Federal appropriation of \$200,000 was originally made, to be available until expended; but in three years this experiment in cooperative forest protection—for it was admittedly only an experiment—had sufficiently progressed to satisfy Congress that a yearly appropriation was needed.

It was not, however, until the Clarke-McNary law superseded the Weeks law in this field, on June 7, 1924, that a definite Federal responsibility to protect private and State forest lands as such from fire was recognized. It took form in an authorization of Federal appropriations of \$2,500,000 annually, which is based on the premise that the total estimated annual cost for all private and State lands needing protection, \$10,000,000, should be borne equally by the private owners and the public, with the public share divided equally between States and the Federal Government.

A survey of the progress made in these 17 years of cooperation shows a really remarkable growth. Beginning with 11 States, cooperation is now extended to 38, no less than 25 of which were stimulated to adopt protection by the offer of Federal cooperation. As new States have come in, it has been evident that the backing from Federal cooperation has helped to stabilize the protection once it was started, to place it on a permanent footing, and to extend it. The moral support of the Federal Government, the community of interest between the Government and States, and the joint effort to develop a new State function in furtherance of that interest have all counted heavily in the progress of the cooperation.

Annual expenditures by the States have increased from a few hundred thousand dollars to \$2,000,000, and the same is true of expenditures by pri-

vate owners. Federal expenditures, though still less than half the \$2,500,000 contemplated by the Clarke-McNary law, have risen from \$50,000 to \$1,200,000. The area of State and private forest lands protected has been extended to over 200,000,000 of the 381,000,000 acres in need of protection. Yet with this remarkable showing the States and private owners together are meeting their responsibility in the matter by less than 60 per cent and the Federal Government its responsibility by only 40 per cent. Larger provision must be made.

The satisfactory showing already made in funds appropriated and acreage protected has been accompanied by an even greater progress in the handling of the protective work and in the results obtained. The administration of the work by the States is becoming less and less political and more and more efficient, which has made for larger returns on the money expended. The fire loss, in acreage burned and damage incurred, has been materially decreased. This is the real measure of progress. There has been an enormous increase in the exposure to fire, in consequence of greater facilities for travel and more people getting into the woods. There has also been an enormous increase in the cut-over areas, often highly inflammable. During 1926, which was a year of severe fire damage in various regions, nearly 85,000 fires were reported on private and State forest lands, the largest number on record. Nevertheless, the area burned, 23,500,000 acres, and the damage, \$22,000,000, were appreciably below the previous year, which was itself rather under the average in both items.

The Clarke-McNary law greatly broadened the cooperative work in other ways than by removing the restriction that limited protection to the watersheds of navigable streams. It laid down a comprehensive program of national forestry. It directed the Secretary of Agriculture to cooperate with the States or other suitable agencies for the study and devising of tax laws with a view to encouraging timber growing and for the promotion of timber insurance. No timber-insurance studies have yet been made, but tax studies have been under way for the past three years; they are discussed in another part of this report. The law also provided for the cooperative encouragement of farm forestry through distributing forest planting stock and through assistance in the practice of forestry.

The purpose was to enable the farmer to get the kind and quantity of trees needed for his shelter belt or wood lot at a cost which he can afford, and to get the assistance which he needs in growing timber crops. Admirable as were these provisions, they obviously should be extended to cover lands in all classes of ownership, including lands owned by States, municipalities, and especially the larger forest owners. To do so would greatly broaden the cooperative field of education and demonstration, and would undoubtedly lead to a more general practice of private forestry. The latter should be through the employment by large landowners of competent private practitioners, not through the development of a free service provided at public expense; the public function should be limited to showing the way.

State legislation, administration, education, and demonstration are helping to make private timber growing profitable. The essential first step in State forestry is the organization of a forestry department, now established in 44 of the States and in nearly all within the past two decades. The outstanding effort in the timber States is very naturally fire protection, while that in the Great Plains is the establishment of shelter belts and wood lots on the farms. Great strides have been made in analyzing the causes of forest fires and taking the necessary steps to reduce the hazard. Disposal of slash and debris after logging is increasingly required; brush burning by farmers is being controlled through requiring permits to burn; railroad fires are more and more successfully controlled. Such basic means of reducing man-caused fires are permitting the State protective systems to function on an increased basis of efficiency.

A rapid development of forest-tree nurseries in the States is the result of an enormous increase in the demand for planting stock by private owners. Last year the number of trees distributed to private owners, mostly at cost, was close to 60,000,000, of which New York and Pennsylvania produced approximately 25,000,000 and 15,000,000, respectively. Yet with all that Federal and State agencies are accomplishing cooperatively to induce private owners to reforest their cut-over lands and to make it profitable for them to engage in growing timber, there is an enormous further field for education and demonstration work. The Forest Service is so shaping its

public relations activities as to cooperate with the States and private owners on a larger educational plan than has been possible hitherto, and every effort will be made to obtain increased participation in fire prevention and continuous timber production.

PROGRESS IN STATE FORESTRY LEGISLATION

Tax relief is being given serious consideration in various States. Notable among the forest tax laws that have been passed, and in the forestry legislation enacted during the past year, is that of Wisconsin, the first and as yet the only State to recognize the principle of financial assistance to the local taxing unit during the period of exemption or until returns from the yield tax begin to come in. A tax on cut-over land of 10 cents an acre is to be matched by a like payment from the State, the latter to be eventually compensated through a yield tax of 10 per cent of the value of the forest products when harvested. This law supplemented the constitutional amendment mentioned in last year's report.

Although few State legislatures held sessions last year, considerable other forestry legislation was enacted. Of greatest significance is that looking to enlarged public ownership and administration.

Mention was made in last year's report of the introduction in the New York Legislature of a resolution contemplating a constitutional amendment to authorize a bond issue of \$100,000,000 for buying and reforesting lands during a 20-year period. At last winter's session the legislature created a temporary commission to investigate the subject of reforestation generally, to gather data on the lands not suitable for agriculture which might be utilized for that purpose, and to report upon the best means of promoting and financing the work. In other words, legislation has been passed to ascertain the facts and to devise a practicable course of action. The comprehensive scale upon which this work is planned may be widely influential in other States. New York also authorized villages to acquire and use lands for forestry purposes, and authorized the State conservation department to establish and manage new State parks and parkways in the forest preserve and certain other counties and to acquire land for them as appropriations for purchases are made.

Wisconsin changed its single-headed conservation commission to one of six members, with power to employ a conservation director; revised and ex-

panded the commission's general powers and duties for the protection, development, and use of forests; and increased from 100,000 to 500,000 acres the authorization for Federal land acquisition for national forests, the general boundaries to be subject to approval by the county boards. Porto Rico likewise authorized the United States to acquire land for the extension of its national forest.

Alabama passed a progressive measure looking to the discovery by the State commission of forestry of all lands to which the State, its institutions, or departments are entitled, but which have not been received, and to the classification of all lands of the State or its townships from the standpoint both of their present use and of that for which they are chiefly valuable. State lands not being utilized for the immediate purposes of the individual institutions or departments, and all State parks, are placed under the jurisdiction of the commission, which is required to protect and recommend policies for them, may recommend exchanges of scattered tracts to consolidate ownership, and must determine and list with the auditor all State unused lands which are best suited to forest culture. Thereafter at the direction of the governor lands so listed are to be administered by the commission as either State forests or State parks.

Somewhat similarly, West Virginia created a State forest and parks commission (consisting of the governor and four other State officials) to investigate lands held by the State, including lands forfeited through non-payment of taxes; to determine their availability for State forests or parks; and to report to the next legislature, with recommendations for legislation, regarding how best to cooperate with the Federal Government in connection with its plans for the Monongahela National Forest, regarding State forests and parks generally, and specifically regarding the availability and usefulness for forest or park purposes of various named areas.

Kentucky, in anticipation of Federal purchases within that State for national-forest purposes, provided that moneys accruing from national forests shall be apportioned to the several counties in proportion to the national-

forest area in each, for public schools and roads. Massachusetts made provision for forest-fire patrol in certain towns on Cape Cod. New Jersey extended its forest fire protection laws to include salt marshes or meadows, and New York increased the maximum pay of fire wardens and fire fighters and empowered the conservation department to enter into cooperative agreements with municipalities and persons for fire control.

WORK OF THE YEAR IN STATE COOPERATION

The appropriations for cooperative work with States during the fiscal year 1928 compared with those for the previous year and those for the fiscal year 1929 are shown in Table 1.

TABLE 1.—*Appropriations for State cooperation, 1927-1929*

Item	Amount appropriated for fiscal year—		
	1927	1928	1929
For the prevention and suppression of forest fires and for the forest taxation inquiry (secs. 1-3 of the Clarke-McNary law)-----	\$710,000	\$1,000,000	\$1,200,000
For the distribution of forest planting stock to farmers (sec. 4 of the same law)-----	75,000	75,000	75,000
For farm forestry extension (sec. 5 of the law)-----	50,000	60,000	60,000

The Federal expenditures last year under the first and second items appear in the statement of expenditures on page 59. The appropriation under the third item is expended by the Extension Service of the Department of Agriculture. The results of the work are summarized below, except for the taxation study, which is covered on page 55. Table 2 shows in detail the Federal, State, and private funds disbursed by the States or expended under their direct supervision for the prevention and suppression of forest fires, and the Federal and State funds disbursed by the States for the distribution of planting stock.

TABLE 2.—Cooperative expenditures in fire protection and the distribution of forest planting stock under the Clarke-McNary Act, fiscal year 1928

State	Fire protection				Distribution of forest planting stock		
	Federal	State	Private agencies	Total	Federal	State	Total
Maine.....	\$36,897.33	\$151,080.27	-----	\$187,977.60	\$1,499.88	\$1,550.76	\$3,050.64
New Hampshire.....	12,136.00	39,483.72	\$7,988.58	59,608.30	2,052.78	5,273.37	7,326.15
Vermont.....	7,028.00	7,105.64	6,404.21	20,537.85	2,200.00	6,944.16	9,144.16
Massachusetts.....	19,420.00	82,438.94	-----	101,858.94	2,200.00	10,293.75	12,493.75
Connecticut.....	6,166.95	34,850.56	5,117.51	46,135.02	2,000.00	3,060.70	5,060.70
Rhode Island.....	983.00	4,121.99	-----	5,104.99	-----	-----	-----
New York.....	42,472.00	217,976.28	-----	260,448.28	4,100.00	88,083.47	92,183.47
New Jersey.....	10,504.00	86,610.11	-----	97,114.11	2,100.00	5,357.41	7,457.41
Delaware.....	765.00	997.67	-----	1,762.67	2,000.00	2,880.00	4,880.00
Pennsylvania.....	37,628.00	205,519.33	-----	243,147.33	2,800.00	25,826.65	28,626.65
Maryland.....	6,809.00	25,597.92	2,640.82	35,128.74	2,100.00	6,841.03	8,941.03
Ohio.....	2,913.00	18,987.12	-----	21,900.12	2,200.00	16,357.91	18,557.91
Illinois.....	525.70	3,608.62	1,050.00	5,184.32	-----	-----	-----
Indiana.....	1,609.03	1,722.29	-----	3,331.32	2,137.94	13,127.89	15,265.83
Iowa.....	-----	-----	-----	-----	2,000.00	2,946.37	4,946.37
Virginia.....	32,491.00	33,018.38	10,258.00	75,767.38	2,000.00	2,526.14	4,526.14
West Virginia.....	18,232.00	37,274.14	17,123.55	72,629.69	200.00	248.75	448.75
North Carolina.....	41,438.00	43,103.59	2,694.19	87,235.78	2,000.00	3,271.19	5,271.19
South Carolina.....	3,400.00	639.09	8,451.84	12,490.93	-----	-----	-----
Kentucky.....	10,114.50	10,114.50	-----	20,229.00	1,684.70	2,166.93	3,851.63
Tennessee.....	22,750.00	19,697.69	8,737.09	51,184.78	1,000.00	1,016.00	2,016.00
Georgia.....	38,338.00	10,584.64	30,088.55	79,011.19	800.00	800.00	1,600.00
Florida.....	9,000.00	9,000.00	-----	18,000.00	35.00	35.00	70.00
Porto Rico.....	-----	-----	-----	-----	2,300.00	15,844.16	17,844.16
Alabama.....	41,760.00	36,051.15	21,708.28	99,519.43	1,058.97	1,058.97	2,117.94
Louisiana.....	35,607.00	40,569.21	62,165.20	138,341.41	2,100.00	10,653.21	12,753.21
Mississippi.....	33,655.00	13,623.57	45,997.44	93,276.01	-----	-----	-----
Texas.....	30,862.00	30,774.43	3,012.70	64,649.13	-----	-----	-----
Oklahoma.....	13,710.00	6,790.65	8,007.00	28,507.65	2,000.00	2,730.74	4,730.74
Missouri.....	6,747.36	6,654.36	93.00	13,494.72	1,600.00	1,635.34	3,235.34
Michigan.....	54,804.00	304,311.00	-----	359,115.00	2,100.00	5,534.27	7,634.27
Wisconsin.....	27,276.00	72,067.68	-----	99,343.68	2,000.00	5,443.14	7,443.14
Minnesota.....	60,933.00	180,587.78	-----	241,520.78	-----	-----	-----
Kansas.....	-----	-----	-----	-----	2,000.00	4,000.02	6,000.02
Nebraska.....	-----	-----	-----	-----	2,000.00	4,112.00	6,112.00
Colorado.....	-----	-----	-----	-----	1,776.00	2,022.41	3,798.41
South Dakota.....	375.00	4,821.85	-----	5,196.85	-----	-----	-----
Wyoming.....	-----	-----	-----	-----	1,000.00	1,519.68	2,519.68
North Dakota.....	-----	-----	-----	-----	2,100.00	9,437.50	11,537.50
Montana.....	18,708.00	15,892.14	39,324.41	73,924.55	2,000.00	2,628.62	4,628.62
Idaho.....	35,608.00	52,505.23	129,466.88	217,580.11	1,171.00	1,201.00	2,372.00
Washington.....	50,955.00	107,689.65	205,328.90	363,973.55	2,000.00	2,778.15	4,778.15
Oregon.....	48,442.00	42,783.79	213,462.17	304,687.96	2,000.00	2,715.20	4,715.20
California.....	44,985.00	110,901.54	168,723.04	324,609.58	942.50	1,759.91	2,702.41
Hawaii.....	-----	-----	-----	-----	1,805.26	28,282.67	30,087.93
New Mexico.....	1,826.00	5,149.00	-----	6,975.00	-----	-----	-----
Administration and inspection.....	73,320.85	-----	-----	73,320.85	175.00	-----	175.00
Total.....	941,275.72	2,074,705.52	997,843.36	4,013,824.60	69,239.03	301,664.47	370,903.50
Forest tax studies.....	49,838.05	-----	-----	-----	-----	-----	-----
Cost of Norway pine seed on hand June 30, 1928, subject to requisition by cooperating States.....	-----	-----	-----	-----	5,737.95	-----	5,737.95
Unexpended balance.....	8,886.23	-----	-----	-----	23.02	-----	-----
Total appropriation.....	1,000,000.00	-----	-----	-----	75,000.00	-----	-----

In addition to the expenditures for fire protection shown in Table 2, probably in excess of \$1,000,000 was expended independently by private individuals and associations. In some States a very substantial contribution is thus made to the total protective work.

COOPERATIVE PROTECTION OF STATE AND PRIVATE FORESTS FROM FIRE

Cooperative study of protection requirements for each forest region of the United States is authorized and required by section 1 of the Clarke-McNary law. State forestry departments were the agencies cooperated with, and the studies made concerned their forest-fire protection problems and the formulating or approving of programs and plans calculated to provide adequate protection. Such studies were completed in Mississippi, Oklahoma, Wisconsin, and Virginia.

The Cape Cod forest-fire prevention experiment, begun in January, 1926, was continued. Its aim is to determine the effectiveness of intensive educational prevention work in fire control, as against suppression work solely. From the start there has been a marked and continuous reduction both in the area burned and in the cost of protection.

Progress was made upon studies in Washington and Oregon. In the Southeast fact-finding surveys are being continued. The aim will remain to formulate a program for each region or State, to which all parties are agreed and for which all will strive.

Cooperative agreements for organized fire protection were in force with

38 States, or 5 more than the previous year; the new States were Indiana, Illinois, Delaware, Florida, and South Carolina. All States having substantial areas of State and private forest land in need of protection are now cooperators in this activity except Arkansas. The area covered in the calendar year 1927, about 202,000,000 acres, exceeded that in 1926 by 14,000,000 acres. Yet only 54 per cent of the entire amount needing protection was covered, and a substantial part of that very inadequately.

For the area under protection the 1927 record (shown in Table 3) compares very favorably with that of 1926. With 4 per cent more fires, the area burned was over 40 per cent less. More substantial progress is indicated in the suppression than in the prevention of fires. Including unprotected lands, however, the total area burned in 1927 was 59 per cent greater than in 1926. This was due to severe fires in the relatively unprotected southeastern and Gulf regions, where nearly 35,000,000 acres were burned on areas classed as unprotected. It is significant that while only one-third of the area needing protection is unprotected, 93 per cent of the total area burned was on this third. It is true that the record of fires on unprotected areas is not complete or accurate. After all allowances have been made, however, for inaccuracies in the data it is obvious that the greatest single immediate need is to extend protection to the 170,000,000 acres and more of forest land which is still in the unprotected class.

TABLE 3.—*Summary of forest fire statistics, by groups of States, for the United States, exclusive of Alaska, calendar year 1927*

[Figures for unprotected areas based upon partial information only]

Group of States ¹	Number of fires				Damage			
	On protected area	On unprotected area	Total	Per cent	On protected area	On unprotected area	Total	Per cent
United States.....	35,300	123,138	158,438	100.0	\$4,297,400	\$29,088,200	\$33,385,600	100.0
Northeastern.....	4,449	-----	4,449	2.8	800,380	-----	800,380	2.4
Middle Atlantic.....	2,516	99	2,615	1.7	399,320	95,040	494,360	1.5
Southeastern.....	2,142	26,734	28,876	18.2	483,520	13,837,960	14,321,480	42.9
Gulf.....	12,989	85,341	98,330	62.1	998,010	14,421,780	15,419,790	46.2
Central.....	899	10,932	11,831	7.5	183,910	670,410	854,320	2.5
Lake.....	3,130	-----	3,130	1.9	100,820	-----	100,820	.3
Rocky Mountain.....	2,569	29	2,598	1.6	29,550	12,530	42,080	.1
Pacific.....	6,606	3	6,609	4.2	1,301,890	50,480	1,352,370	4.1

Northeastern group—New England States and New York. Middle Atlantic group—New Jersey, Pennsylvania, Delaware, and Maryland. Southeastern group—Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida. Gulf group—Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas. Central group—Kentucky, Tennessee, Ohio, Indiana, Illinois, and Missouri. Lake group—Michigan, Wisconsin, and Minnesota. Rocky Mountain group—Montana, Idaho, Wyoming, South Dakota, Colorado, Arizona, New Mexico, Nevada, and Utah. Pacific group—Washington, Oregon, and California.

TABLE 3.—*Summary of forest fire statistics, by groups of States, for the United States, exclusive of Alaska, calendar year 1927—Continued*

AREA, IN ACRES, BURNED

Group of States ¹	On protected area							On un-protected area	Grand total	Per cent
	Forest land				Non-forest land	Total	Per cent			
	Mer- chant- able or mature tree growth	Unmer- chant- able or im- mature tree growth	No. tree growth at present	Pro- tec- tion for- est						
United States.....	587,070	1,095,020	441,700	85,580	575,080	2,784,450	100.0	35,747,380	38,531,830	100.0
Northeastern.....	20,680	45,650	48,210	-----	10,440	124,980	4.5	-----	124,980	.3
Middle Atlantic.....	17,730	39,430	13,920	-----	3,190	74,270	2.7	11,880	86,150	.2
Southeastern.....	117,920	198,430	36,460	580	21,950	375,340	13.5	16,481,770	16,857,110	43.8
Gulf.....	316,200	624,210	242,680	5,340	8,710	1,197,140	43.0	18,336,870	19,534,010	50.7
Central.....	59,330	34,310	1,510	-----	360	95,510	3.4	809,560	905,070	2.3
Lake.....	490	61,150	55,010	-----	19,950	136,600	4.9	-----	136,600	.4
Rocky Moun- tain.....	10,970	4,330	2,230	2,570	1,250	21,350	.7	13,360	34,710	.1
Pacific.....	43,750	87,510	41,680	77,090	509,230	759,260	27.3	93,940	853,200	2.2

¹ Northeastern group—New England States and New York. Middle Atlantic group—New Jersey, Pennsylvania, Delaware, and Maryland. Southeastern group—Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida. Gulf group—Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas. Central group—Kentucky, Tennessee, Ohio, Indiana, Illinois, and Missouri. Lake group—Michigan, Wisconsin, and Minnesota. Rocky Mountain group—Montana, Idaho, Wyoming, South Dakota, Colorado, Arizona, New Mexico, Nevada, and Utah. Pacific group—Washington, Oregon, and California.

COOPERATION WITH THE STATES IN TREE PLANTING

On July 1, 1925, when the Clarke-McNary law became effective, 18 States were distributing forest trees to their citizens for planting as against 37 States and 2 Territories which are now receiving Federal co-operation in this work. Public demand for low-priced forest trees so necessary to reforestation is extensive and growing. Last year five new States, Georgia, Florida, Mississippi, Tennessee, and West Virginia, received this form of aid.

Many of the cooperating States have difficulty in obtaining tree seeds at a reasonable cost. Particularly has this been true of Norway pine, which is being extensively planted in Northern States. The Forest Service therefore inaugurated last fall a cooperative seed collection and extraction project on the Chippewa National Forest in Minnesota. The States which shared in the cost were furnished 1,931 pounds of Norway and 269 pounds of white pine seed at a relatively low cost per pound, and 1,400 pounds more is still available. There is probably enough Norway pine seed to meet the needs of the cooperating States for the next two or three years. To insure a steady and reliable supply of seed for their own needs, New York

and Louisiana have erected State extraction plants.

Farmers throughout the country are becoming steadily more appreciative of the desirability of keeping their woodlands fully stocked and of making their idle acres produce timber crops. Last year they planted with young trees over 30,000 acres of farm lands, and the cooperating States distributed to them nearly 28,000,000 trees to plant, while additional stock was purchased by farmers from private nurseries.

The allotments made to the States cooperating and their expenditures were shown in Table 2.

COOPERATION WITH THE STATES IN FARM-FORESTRY EXTENSION

Two new States included forestry in their agricultural-extension programs, bringing the number to 31. This work, authorized under section 5 of the Clarke-McNary law, is conducted as a part of the extension program of the several State agricultural colleges and is administered by the Extension Service of the department with the cooperation of the Forest Service. The Federal appropriation for the year of \$60,000 was used mostly for the employment of extension foresters.

In number of projects planting took first place. County agricultural agents reported 6,082 forest plantings, covering 19,455 acres, and 1,924 wind-breaks. The management of already established farm woodlands, though of greater economic importance than forest planting on waste farm lands, does not so easily appeal to the owner. Nevertheless 4,509 farmers received assistance toward the management of 222,135 acres of woods. An interesting development of the work was the employment in Chautauqua County, N. Y., of an assistant county agent to serve as county forester.

The most notable feature of the year was the extent to which forestry was taken up by the boys and girls of the 4-H clubs. In addition to forest planting and projects designed to inculcate a better knowledge of the forest and forest values the management of pieces of farm woods was undertaken, with thinnings and improvement cuttings; and in Louisiana, in cooperation with the State forester, a plan was developed for protecting woodland from fire. In all, 3,163 boys and girls, largely in five States, enrolled in forestry projects, and 2,192 carried their work to completion.

NATIONAL-FOREST ADMINISTRATION

The total cost of national-forest administration, protection, improvement, and extension last year, exclusive of expenditures for the administration of the Forest Service as a whole (i. e., general overhead) was \$20,117,615.90. This was less by \$1,237,800.96 than the cost for the fiscal year 1927. A relatively favorable fire year reduced the expenditures for protection by \$1,581,665.02, and \$895,909.47 less was spent on road and trail construction and maintenance; but \$998,551.99 more was spent for land purchases, and smaller increases took place in various items.

As the statement of expenditures and receipts on page 59 shows, the cost of administering the current business on the national forests was considerably less than half the receipts. The basic object of the public enterprise, however, is not money returns but public benefits of many kinds. It is true that the taxpayers of the country have a right to expect that the national forest administration will seek to make their burden as light as possible—that in making expenditures it will have careful regard for econ-

omy and that commercial uses of the forests will be made revenue producing in accordance with and on the basis of their value. There is ground for satisfaction that the cost of operating the forests is being more than met by the cash receipts, mainly from timber and grazing. But in addition large and important returns to the general welfare were realized; and these were the real profits of the enterprise.

The national forests are, of course, public investments. In connection with the census estimate of the national wealth, made in 1922, their value was put at \$1,053,191,993. This represented a theoretical appraisal of great land areas largely having no established market value. While any attempt to set up a money equivalent for them is necessarily guesswork, the fact remains that when the forests were established they already represented a very substantial public investment; and each year adds to the total. The forest resources are steadily appreciating national assets. The major part of the annual outlay upon them is for their development, equipment, and extension, and under the accounting methods of private business would be properly chargeable to capital account. Even the cost of protection is largely an expenditure for the future, or carrying charge. The character of the public enterprise necessitates substantial outlays to establish, equip, and develop the forests, and it is sound business policy to add in this way to what in a balance-sheet statement would be recorded as the book value of the investment.

The administrative and protective improvements on the national forests, exclusive of roads and trails, have a present inventory value of \$6,365,743. These include lookout towers and houses, telephone lines, ranger quarters, etc. At the close of the fiscal year there were 14,822.6 miles of road and 39,594.6 miles of trail, representing a total outlay of \$72,717,912.02 of Federal and \$16,879,492.78 of cooperative funds. In addition there are range and recreation improvements constructed at a total cost of \$1,233,739, partly Federal and partly cooperative funds. These various classes of improvements have added enormously to the public usefulness of the forests and to their value as properties.

The appropriations of Federal funds for the national forest enterprise in the fiscal years 1927, 1928, and 1929 compare as shown in Table 4:

TABLE 4.—*Appropriations of Federal funds, 1927-1929*

Item	1927	1928	1929
General expenses of administration, protection, and improvement.....	\$6,358,838.00	\$6,488,865.00	\$6,814,600.00
Specifically for—			
Fire and insect control.....	2,488,000.00	1,180,107.46	71,892.54
Improvements, tree planting, land and resource surveys, and land adjustments.....	862,150.00	880,450.00	996,450.00
Land acquisition.....	1,000,000.00	1,994,843.40	1,005,156.60
Roads and trails (construction and maintenance) needed primarily for forest protection and development.....	2,876,705.03	4,654,086.78	3,540,511.91
Highway construction and maintenance primarily to meet public needs, as a recognition of Federal responsibility created by ownership of untaxed lands.....	4,037,500.00	4,240,000.00	4,500,000.00

Contributed cooperative funds brought the total available for 1927 to \$19,224,421.08, and for 1928 to \$20,926,170.03. In addition, the appropriations for roads and trails were augmented by unexpended balances from earlier years. The total so carried forward into the fiscal year 1927 was \$2,822,815.76; into 1928, \$5,019,167.12; and into 1929, \$4,462,848.45. Both because of this carry over and because most of the road funds become available for expenditure as soon as the appropriation act carrying them is passed, road and trail expenditures for individual years do not correspond closely with the appropriations.

The increase for 1928 over 1927 shown in the third item was made to provide \$18,300 more for tree planting; and that shown in the first item provided \$70,500 more for fire guards and other forms of preparedness, \$46,000 for increased personnel to handle the expanding timber-sale business and the grazing work, \$10,527 for administering the military-reservation national forests, and \$3,000 for the purchase and establishment on the Wichita National Forest of a herd of longhorn cattle.

The 1929 further increase in the third item represents \$60,000 more provided for tree planting, \$52,000 for the construction of improvements to assist in fire control—of which \$25,000 was for use in southern California—and \$9,000 for the construction of a dam on Cass Lake in Minnesota. The 1929 gain in the first item (\$325,735) was partly due to a shift into this item of \$75,000 formerly carried in the second item. It also provided \$37,800 more for the timber sale and range management work and \$238,528 more for the payment of salaries and expenses in connection with fire control. On the other hand, decreases totaling

\$25,593 were effected by dropping the longhorn cattle herd item (the work having been accomplished), by curtailing slightly the provision for Washington office expenditures in connection with national forest administration, and by carrying to the appropriation for the Federal Power Commission \$19,400 previously used to perform work required by that body.

The showing under the item "Specifically for fire and insect control" needs comment. The greater part of the cost of fighting forest fires is covered, not by appropriations made in advance, but by subsequent deficiency appropriations according to the amount required. Severe conditions in 1927 necessitated a deficiency appropriation in that year of \$2,155,000. The 1928 deficiency appropriation of \$769,000 was supplemented by \$78,107.46 from a 1929 \$100,000 fire fund; only the remaining balance therefore appears as appropriated for 1929. A 1929 deficiency appropriation of at least \$1,000,000 will probably have to be sought when Congress convenes.

In bad fire years the funds available for general expenses of administration, protection, and improvement are drawn upon much more heavily for fire control than in normal or exceptionally favorable years, and the deficiency appropriations in the severe years only partly meet the extra cost. In other words, the regular appropriations have a degree of fluidity which causes considerable fluctuation in the amounts available from year to year for other purposes than protection.

With regard to the fourth item in the comparative statement of appropriations, it should be said that both the 1928 and the 1929 agricultural appropriation acts provided \$1,000,000 for land acquisition. Following the enactment of the McNary-Woodruff law au-

thorizing a 1929 appropriation for this purpose of \$2,000,000, another \$1,000,000 was provided for 1929 in a deficiency act, but with the provision that it should be available for immediate expenditure. This was to permit exercise of an option to purchase the so-called Waterville tract, in New Hampshire, which otherwise would have lapsed. The expenditure actually made in 1928 is included in the amount shown as appropriated for that year and is correspondingly deducted from the 1929 total.

The two chief expenditure items in administering the national forests are improvements and protection. These are closely related. The first and most imperative reason for equipping the forests with improvements has been to lessen the cost and increase the efficiency of protection.

As is stated later on this page, the national forests include within their boundaries more than 184,000,000 acres. When originally established they were principally vast areas of primeval wilderness. Their protection called for almost superhuman efforts, was expensive in comparison with what could be done, and yet left the forests exposed to severe losses. Fires had to be fought by men barehanded, so to speak; there was no system either for detection or suppression. It often took days and sometimes weeks to cut a way through to a fire, and the provision made for detection was as primitive, unequipped, and defective as that for suppression.

As is mentioned in the section dealing with roads and trails, a multitude of concrete cases could be cited in which roads and trails have been the direct means of saving the Government, sometimes in a single year, far more than they cost to build. Protection improvements making it possible first to discover and report fires quickly and then to attack them swiftly are invaluable aids to keeping down losses and employing to good advantage the funds spent each year in fire control. In short, adequate equipment of the forests with the improvements necessary to preserve their resources and to enable the public to use them is basic to carrying out the purpose for which they were created and is a highly economical form of expenditure.

While large progress has been made, much remains to be done before the forests will be properly equipped for economical and efficient protection and for rendering fully to the public the services and benefits which constitute

the real returns on the national investment in them. The section dealing specifically with their protection against fire indicates in more detail the urgent needs from that standpoint. It is important also to increase their value for timber production by enlarging greatly the tree-planting work.

As already noted, the 1928 appropriations provided for some enlargement of this work, and those for 1929 have considerably but by no means adequately increased the provision. The creation of new purchase areas in the Lake States and the South, mentioned on page 22, increases the need. These new areas will be made up largely by the purchase of lands on which a valuable timber crop can be established only through tree planting. On the already-existing national forests extensive areas await planting to become productive. They are largely old burns denuded of valuable timber growth before the national forests were created, and still not restocking. New fires add each year something to such areas, and in bad seasons add far more than is replanted at the present far too meager rate. Not counting such additions and the enlarged requirements that will be imposed by the new acquisition program, at the rate of last year's planting, totaling only 12,803 acres, more than 160 years would be necessary to complete the reforestation definitely needed now. This is another form of investment that should be recognized as both profitable and essential to proper development of the forests as useful public properties.

THE NATIONAL-FOREST PROPERTIES

The gross area of the national forests on June 30, 1928, was 184,403,819 acres, of which 24,922,963 acres was not owned by the United States. The net area was therefore 159,480,856 acres. The gross area increased 465,713 acres, the net area 680,432 acres.

By Executive orders, 169,502 acres of military reservations, administration of which as national forests was found impracticable under the plans of the War Department, were removed from national-forest status. This abolished the national forests on Camp Benning, in Georgia; Camp Dix, in New Jersey; Camp Eustis, in Virginia; Camp Jackson, in South Carolina; Camp Knox, in Kentucky; Camp Lee, in Virginia; Camp Meade, in Maryland; Camp McClellan, in Alabama; and Camp Pine Plains, in New York. On the other hand, area recomputations based on better surveys and land

data raised the gross area showing by 57,648 acres; 31,741 acres were added by exchanges consummated with private owners of lands adjoining the old forest boundaries; and 39,000 acres was acquired in Michigan under section 6 of the Clarke-McNary law and thereby automatically added to the Michigan National Forest. All other gross area changes of the fiscal year are listed in Table 5.

TABLE 5.—*Additions to and eliminations from the gross areas of the national forests made by acts of Congress, Presidential proclamations, Executive orders, and State land exchanges*

National forest	State	Additions /	Eliminations
		<i>Acres</i>	<i>Acres</i>
Challis.....	Idaho.....	¹ 76, 379	
Cherokee.....	Georgia, North Carolina and Tennessee.....	² 200, 188	² 186, 230
Chugach.....	Alaska.....	³ 7, 361	
Columbia.....	Washington.....		³ 1, 938
Colville.....	Washington.....		³ 275
Crater.....	Oregon.....	¹ 27, 547	
Gunnison.....	Colorado.....	¹ 6, 364	
Harney.....	South Dakota.....		³ 2, 883
Harney.....	South Dakota.....		¹ 1, 600
Idaho.....	Idaho.....	¹ 46, 086	
Lassen.....	California.....		¹ 80
Manti.....	Utah.....	² 125	
Missoula.....	Montana.....	¹ 227, 533	
Montezuma.....	Colorado.....	¹ 21, 557	
Natural Bridge.....	Virginia.....	¹ 1, 200	² 41, 670
Ozark.....	Arkansas.....	² 122, 489	
Plumas.....	California.....	² 4, 900	
San Bernardino.....	California.....		³ 80
Sawtooth.....	Idaho.....	¹ 8, 724	
Sequoia.....	California.....		² 37, 425
Sitgreaves.....	Arizona.....		³ 140
Snoqualmie.....	Washington.....		⁴ 4, 643
Stanislaus.....	California.....	² 10, 146	
St. Joe.....	Idaho.....		⁴ 1, 130
Tongass.....	Alaska.....		³ 1, 314
Umatilla.....	Washington and Oregon.....	² 16, 271	
Wallowa.....	Oregon.....	² 7, 756	
Wenatchee.....	Washington.....	² 161	
Whitman.....	Oregon.....	² 1, 447	

¹ Made by acts of Congress.

² Made by Presidential proclamation.

³ Made by Executive order.

⁴ Made by State land exchange.

The additions to the Challis, Sawtooth, Idaho, Missoula, and Gunnison Forests were approved by the National Forest Reservation Commission under section 8 of the Clarke-McNary Act. The presidential proclamations adding to the Plumas, Stanislaus, Wallowa, Whitman, Wenatchee, and Umatilla Forests were under the authority of specific acts of Congress. The elimination from the Sequoia National Forest in

California was made because the character of the land does not justify its further administration. The 1,600-acre elimination from the Harney National Forest in South Dakota comprised scattered tracts lying within the boundaries both of the forest and the Custer State Park, and were granted to the State for park purposes. Approximately 5,000 acres was conditionally transferred from the Powell National Forest, Utah, to the Bryce Canyon National Park by act of Congress, which also transferred the 80 acres shown as eliminated from the Lassen National Forest to the Lassen Volcanic National Park, to meet administrative needs of the Park Service.

While distinct progress was made during the year toward a logical shaping up of the national-forest properties, much remains to be done. Unreserved and unappropriated public lands chiefly valuable for stream-flow protection or timber production, and near enough to existing national forests to be efficiently and economically managed as parts of them, should be given a national-forest status. It was the purpose of section 8 of the Clarke-McNary law to have the location of such lands systematically determined by the Secretary of Agriculture, and if his findings are approved by the National Forest Reservation Commission to have the facts placed before Congress with a view to action. As already noted, certain additions were made during the year under this procedure. Detailed reports have been made upon a number of other desirable additions.

Several of these additions have been approved by the National Forest Reservation Commission, and the reports upon them have been transmitted to Congress by the President, in accordance with the provisions of section 8 of the Clarke-McNary law. In their present unprotected and undeveloped status these lands, which are too low in productivity to warrant private ownership and management, are rendering little if any service. They are valueless for farming purposes, and their unregulated use for grazing will, in many if not all cases, impair their forest and watershed values. At a time when the Nation is authorizing an enlarged program of forest-land purchases a course under which lands now in national ownership and valuable for timber production or stabilization of stream flow are allowed to remain unprotected, undeveloped, and neglected is difficult of understanding. To the fullest extent practicable such

lands should be made parts of the national-forest system, and nothing of substantial benefit is obtained by delay in accomplishing this.

LAND ACQUISITION THROUGH EXCHANGE

During the year an agreement was reached for selection by the State of California of a compact body of national-forest timbered land in exchange for the State's scattered holdings in the forests. No progress was made in the contemplated exchange with Colorado. The proposed exchange with New Mexico was delayed pending the enactment of a necessary State constitutional amendment. Satisfactory progress was made with the exchanges whereby Michigan, Montana, Oregon, and Washington will obtain solid blocks of Federal lands in place of their scattered holdings within the forests.

New legislation extended the provisions of the general exchange law to Spanish and Mexican land grants partly within or adjacent to the Carson, Manzano, and Santa Fe Forests in New Mexico, and also to private lands within 6 miles of the boundaries of the Crater in Oregon. Congress likewise authorized the exchange of public land outside the Manti in Utah for 640 acres adjoining that forest.

During the calendar year 1927, 135,678 acres of private lands within the national forests were obtained under the general exchange law in return for 7,447 acres of national-forest land and \$420,311 worth of national-forest stumpage, making a net addition to the forests of 128,231 acres. The Secretary of Agriculture approved and referred to the Secretary of the Interior for further action 153 new cases looking to the acquisition of 133,595 acres in exchange for 65,095 acres and 80,146,000 board-feet of stumpage. Since the law was passed 252 exchanges have been consummated and 371,217 acres have been acquired in return for 106,745 acres of national-forest land and \$748,307 worth of national-forest stumpage granted—a net addition of 264,472 acres. Much of the acquired land bears mature timber which eventually will be sold and removed under national-forest regulations, largely offsetting the initial grants of stumpage.

As was said last year, to safeguard against too great a use of national-forest resources for exchanges the Forest Service limits the value of the stumpage to be thus used to 10 per cent of the gross receipts in any State during a single year, and ordinarily

to 10 per cent of the timber-sale receipts alone. In the majority of the Western States the land offered now equals or exceeds what this limit allows to be immediately required. There will be an increasing opportunity to add desirable private lands.

Although a good beginning has been made in national-forest consolidation through land exchanges, there still remain within the forests almost 25,000,000 acres of land not in Federal ownership. These lands are interspersed among the national-forest lands, frequently forming parts of natural logging units or working circles, which for efficient protection and management should be under a single control. It is believed that between 12,000,000 and 14,000,000 acres of this land should eventually be restored to Federal ownership and that the Forest Service should systematically acquire such lands as fast as the owners are willing to reconvey them and national-forest land stumpage is available for exchange. Their acquisition will permit of much more effective forms of forest management, will diminish present costs of protection and administration, and will facilitate the utilization of timber by purchasers.

There are also numerous fringes of land chiefly valuable for forest purposes, outside of but contiguous to the national forests. Because of their private ownership these lands were left outside when the forest boundaries were established, but they form integral parts of natural units of timber management and should be handled with the forests. Further legislation providing for their acquisition through exchange is therefore desirable.

Limited extensions of the exchange authority made by Congress for the Deschutes, Harney, Black Hills, and Crater National Forests and for the Spanish and Mexican land grants contiguous to national forests in New Mexico promise marked enhancement of the public value of these properties as permanent sources of timber supply. A bill extending the provisions of the land exchange law to lands within 6 miles of the national forests in Montana was passed by the Senate last spring, while another bill extending the provisions of the exchange law to lands within 3 miles of the east and west boundaries and 12 miles of the south boundary of the Olympic National Forest in Washington was passed by the House. The lands which would be affected by such legislation are relatively narrow strips between the forest boundaries and the desirable limits of forest growth.

Since they do not in themselves form practicable units of forest management, the removal of the mature timber will unquestionably be followed in most cases by the discontinuance of private protection, and, unless they are added to the national forests, by eventual soil deterioration. Under proper care these lands would remain permanently productive, but if left in a depleted, slash-covered, and unprotected condition they must be not merely useless but a constant menace to the contiguous national forest.

LAND ACQUISITION THROUGH PURCHASE

Title was taken under the Weeks law to 242,121 acres, at a cost of \$1,766,628.84. The average cost per acre, \$7.30, exceeds by \$2.37 the previous average of all years.

Authorized purchases by the National Forest Reservation Commission totaled 261,107 acres and obligated \$1,996,358.04, or \$7.65 per acre. This high average was due primarily to the purchase of the so-called Waterville tract of 23,123 acres in the White Mountains of New Hampshire. The present heavy stand of very valuable timber on this land will in large measure ultimately be sold again, to be cut under provisions adequately safeguarding the exceptional scenic and recreational values involved. The area embraces Mad River Notch and the Greeley Ponds and has one of the few remaining bodies of virgin spruce in New England.

The distribution by States of the lands fully acquired is shown in Table 6.

TABLE 6.—*Acreage of timberland acquired in the fiscal year 1928 and total acquired to July 1, 1928, by States*

State	Acquired in 1928	Average price per acre, 1928	Total acquired to July 1, 1928
	<i>Acres</i>		<i>Acres</i>
Alabama.....	2,236	\$4.99	91,876
Arkansas.....	41,690	2.91	119,378
Georgia.....	5,791	4.54	200,736
Maine.....	874	14.92	33,130
Michigan.....	52,123	1.01	52,123
Minnesota.....	4,093	1.64	4,093
New Hampshire.....	23,565	42.69	450,890
North Carolina.....	5,135	3.08	369,649
Pennsylvania.....	37,062	5.11	251,568
South Carolina.....	1,069	4.24	42,111
Tennessee.....	43,619	4.84	366,409
Virginia.....	12,697	4.26	586,982
West Virginia.....	12,167	4.41	237,495
Total or average.	242,121	7.30	2,806,440

The total purchase cost of lands fully acquired—that is, not including overhead—has been \$14,414,423.93 and the average cost \$5.14 per acre.

The original objective of the Weeks law program was the acquisition of 1,000,000 acres of forest land in the White Mountains and 5,000,000 acres in the southern Appalachians. After 17 years this objective is a little less than one-half attained. In the meantime changes have occurred which make the original objective obviously insufficient. This has been recognized by Congress in the enactment of the Clarke-McNary and Woodruff-McNary Acts.

In the 1926 Report of the Forester a purchase program was outlined which proposed the acquisition of 4,000,000 acres more to complete the Weeks law forests and of approximately 2,500,000 acres in the Lake States and 2,500,000 in the southern pine States, in response to the broadened objectives set up by the Clarke-McNary law. After further study the Forest Service has formulated and the National Forest Reservation Commission has approved a revised and more specific program. It adds to the proposals set forth above the purchase of 600,000 acres in parts of the East where forest and watershed protection is urgently needed, but where no national forest now exists. Particular consideration will be given to the desirability of purchase units in Kentucky and Vermont to meet this need.

While regionally the contemplated purchases conform with the above totals, the revised program recasts the statement in new specifications, which in substance are as follows: (1) For the consolidation of national forests heretofore approved by the National Forest Reservation Commission and situated on the headwaters of navigable streams, 4,000,000 acres; (2) for the establishment of new forests necessary for the protection of headwaters of navigable streams and the reduction of floods thereon, approximately 2,000,000 acres; (3) for the consolidation of national-forest units on watersheds of navigable streams in Michigan and Minnesota, already approved by the commission, primarily to aid in timber production and to demonstrate forestry practice, approximately 1,100,000 acres; and (4) for the creation of new forests in the southern pine region and northern Lake States, primarily to aid in timber production and to demonstrate forestry practice, approximately 2,500,000 acres; total, 9,600,000 acres. This program is exclusive of

areas which, through the present study of the Mississippi flood situation, may prove to be desirable features of a flood-control program on that drainage basin.

Approval of the program was with three conditions: (1) Each new purchase unit to be subject to the enactment of enabling legislation by the State and to the concurrence of the State forest conservation agencies; (2) each new purchase unit to be specifically approved by the National Forest Conservation Commission; and (3) the maximum acreage to be purchased in any State, except for purposes of watershed protection or flood prevention, not to exceed 1,000,000 acres. These conditions amply guarantee proper coordination of Federal purchases with the plans of States and other agencies. As plans take definite form they are being submitted to the State forest conservation agencies for prior comment and concurrence, and no purchase area will be recommended which does not have the full approval of the proper State agencies.

In pursuance of this program, seven new purchase units have been submitted to and approved by the commission, and examinations are now in progress looking to the recommendation of additional units.

Two of the new purchase areas are in Michigan—the Marquette and the Mackinac. The former includes the Marquette division of the Michigan National Forest and contains 250,000 acres to be purchased, with 28,540 acres already owned by the United States. In the Mackinac unit 150,000 acres are to be purchased, while about 2,560 acres are unappropriated public land. The other five new purchase units are in the southern pine region—the Kisatchie, Catahoula, and Vernon units, each containing 50,000 acres, in Louisiana, and the Black River unit of 75,000 acres and the Wambaw of 100,000 acres in eastern South Carolina.

Changes were made in the boundaries of several of the old purchase areas, which do not necessarily coincide with the proclaimed national-forest boundaries and can be modified by the National Forest Reservation Commission without action by the President. To exclude lands more valuable for agriculture than forestry, or lands under effective private forest management, 24,851 acres were eliminated from the Cherokee unit in Tennessee and North Carolina; 116,565 acres from the Georgia unit in Georgia; and 37,972 acres from the

Natural Bridge unit in Virginia. The Ozark and Ouachita units in Arkansas were increased by 122,489 acres and 97,920 acres, respectively.

The present purchase areas contain approximately 12,239,796 acres. They include 1,914,491 acres of public domain, 11,369 acres transferred from the Treasury Department under a special act, and 3,140,938 acres acquired or in process of acquisition under the Weeks law. Of the remaining 7,172,998 acres, 877,500 acres are known to possess agricultural, mineral, or water-power values which preclude purchase. The net unacquired forest land in the existing purchase units is therefore 6,295,498 acres. Some of it is held at prohibitive prices by owners, and some of it is already receiving such care and protection that there is no strong reason for public ownership. Approximately 210,000 acres are now under stable private management.

SPECIAL USES

At the close of the calendar year 1927, 32,430 special-use permits were in effect, of which 15,307 were free and 17,123 involved an annual rental charge. The receipts were \$285,684.12, mainly for hotel, resort, and private-cottage sites. The pay permits increased by 216 and the free permits by 483. Most of the free permits were granted to facilitate the use of other forest land or resources.

Favorable reports were made on 183 and unfavorable on 68 homestead claims, most of them for lands listed under the act of June 11, 1906. The unfavorable reports were usually because the entryman had failed to meet the requirements of the law respecting residence and cultivation.

Applications for listing new lands under the act of June 11, 1906, were for the most part rejected because the lands had already been classified as not chiefly valuable for agriculture. Applicants believing that the classification is erroneous may present for further consideration any facts tending to support the conclusion that the land has a real and permanent value for farming.

Favorable reports were made on 157 and unfavorable on 61 mineral cases. Attempts continue to misuse the mineral land laws in order to get control of forest lands for purposes other than mineral development. It is not difficult in many places to find slight traces of minerals, on the basis of which claims are often located in order that the locator may control the sur-

face, sometimes to use for his own benefit and sometimes to hold up some other legitimate uses of national-forest lands. The trouble became so acute in southern California that the citizens of that region urged legislation which would withdraw from mineral location considerable areas within the Angeles National Forest. An act providing for these withdrawals became a law on May 29, 1928. It, however, gives the President, on the joint recommendation of the Secretary of the Interior and the Secretary of Agriculture, power to restore to mineral location lands so withdrawn which on further examination may be shown to be valuable for their mineral deposits.

COORDINATION OF NATIONAL PARKS AND NATIONAL FORESTS

The coordinating committee on national parks and national forests rescinded its tentative approval of the proposed adjustment of the western boundary of the Yosemite National Park. The subject was referred back to the Forest Service and Park Service for further consideration.

NORTHERN PACIFIC LAND-GRANT HEARINGS

As indicated by the Forester's annual report for the fiscal year ending June 30, 1927, the Attorney General of the United States was directed, by joint resolution dated March 3, 1927, to advise Congress "as to what legal or legislative action should, in his judgment, be taken in the matter of the adjustment of the said Northern Pacific land grants."

Following an exhaustive review of the record of the hearings as presented to the joint committee of Congress, the Attorney General, under letter of February 6, 1928, transmitted to the joint committee an opinion in which it was held that—

not only does no deficiency exist in the grants, but that the company [the Northern Pacific] has already received approximately 5,000,000 acres of public land which it has not earned and is not entitled to, besides additional values.

The opinion concludes that the United States has the right to repeal the granting acts or to declare them forfeited. This opinion sustains the position of the Forest Service that the Northern Pacific Railway Co. is not entitled to take upwards of 2,000,000 acres of national-forest lands in satisfaction of the land grants made by Congress to aid in the construction of the railroad.

Upon receipt of the opinion the joint committee requested the Attorney General to draft a bill embodying the legislation he thought Congress should enact. The bill was not submitted before Congress adjourned. By joint resolution approved May 26, 1928, Congress extended from June 1, 1928, to June 30, 1929, the direction that the Secretary of the Interior withhold the issuance of patents under the Northern Pacific land grants.

PROTECTION FROM FIRE

The number, size, and causes of fires on the national forests in the calendar year 1927, as compared with those of the previous year and the average of the past 5-year period, are shown in Table 7.

TABLE 7.—Comparison of fires on national forests, calendar years 1927, 1926, and 5-year average for period 1923–1927

Classes and causes of fires	Number of fires			Percentage of total		
	1927	1926	Average, 1923–1927	1927	1926	Average, 1923–1927
Class:						
Burns of 0.25 acre or less.....	3,588	3,590	3,596	63.02	50.60	52.17
Burns between 0.25 and 10 acres.....	1,443	2,042	1,906	25.35	28.78	27.65
Burns of 10 acres and over.....	662	1,463	1,391	11.63	20.62	20.18
Total.....	5,693	7,095	6,893	100.00	100.00	100.00
Cause:						
Railroads.....	297	390	318	5.22	5.50	4.61
Lightning.....	3,074	3,387	3,387	54.00	47.74	49.14
Incendiarism.....	397	661	807	6.97	9.31	11.71
Brush burning.....	163	255	226	2.86	3.59	3.28
Lumbering.....	77	119	141	1.35	1.68	2.05
Camp fires.....	596	672	669	10.47	9.47	9.70
Smokers.....	875	1,282	1,082	15.37	18.07	15.70
Miscellaneous.....	214	329	263	3.76	4.64	3.81
Total.....	5,693	7,095	6,893	100.00	100.00	100.00

TABLE 7.—*Comparison of fires on national forests, calendar years 1927, 1926, and 5-year average for period 1923-1927—Continued*

Calendar year	Total area of national-forest land burned over	Total damage of national-forest land burned over	Total cost fighting fires exclusive of time of forest officers
	<i>Acres</i>		
1927.....	170,473	\$298,733	\$646,624
1926.....	776,570	4,563,081	2,167,732
5-year average, 1923-1927.....	412,807	1,465,462	1,106,252

The 1927 showing compares favorably at practically every point with that for 1926 and with the 5-year average. Two outstanding points may be noted: In 1927 the number of man-caused fires was 29 per cent below the number in 1926 and 25 per cent below the 5-year average, and the area of national-forest land burned over was 78 per cent below the area burned over in 1926 and 59 per cent below the 5-year average.

This drop was due to three causes. On the whole the season was favorable—though the number of lightning fires in 1927 was close to the average. Secondly, the executive management of fire-control activities has improved with accumulated experience, study, and insistent pressure for better performance all along the line. Thirdly, the funds available for fire guards, training, and equipment were increased.

The 1928 fire season to the close of the fiscal year and well through July gave promise of an unusually good record. This was primarily because of rains in the northern Rocky Mountains and northern Pacific States, which both shortened the period and materially lessened the severity of the customary summer drought. The rains, however, did not extend into California to any appreciable degree, and the season in that State was of much more than average severity.

While most of the acreage burned over lay outside the national forests and the fires on the forests were mainly kept out of the heavy timber, they taxed to the utmost the protective organization. As the season advanced the conditions grew worse, and at the date of this report the California district is carrying a peak load. The north Pacific district also has been confronted with a trying situation in August in consequence of a period of abnormally high temperature, wind, and low humidity.

Public interest in the control of forest fires is becoming greater and

greater, and nowhere is this more conspicuous than in California. Especially in southern California, but very markedly also throughout nearly all of the State, the interest in fire prevention is intense. In consequence the Forest Service is receiving a large amount of cooperation from counties, towns, organizations of various kinds, and individual corporations and citizens.

The press of the State has actively and effectively backed protection and has done much to build up a strong sense of the need for it and a public demand that fire control must be achieved. All over the country, indeed, the subject is of such general interest that forest fires which a few years ago would have gone unnoticed are now given a prominent place in the daily news; and this to some extent tends to give an exaggerated impression of the actual losses.

While the losses are far greater than they should be and the public demand for better protection is well based, enormous progress has been made in developing efficient methods of control. Every year brings improvement. The Forest Service has always considered protection of the national forests its first duty. It presents problems of great difficulty and requires the creation and application of highly specialized knowledge and skill, as well as a large provision of equipment and works of control. In the nature of things, an adequate protective system can be brought into existence only through assiduous study, long-continued effort, and many setbacks. Much remains to be learned, and much remains to be done before practice will be abreast of what has already been learned, but the protective system of to-day is markedly superior to that of even a few years ago.

Efficient protection includes measures that lessen the likelihood of fires; systematic plans and provisions beforehand for instant action of the right kind and necessary amount when the

need for action develops; means for swiftly spotting, correctly locating, and immediately reporting all fires that start; and as soon as the alarm is received, prompt, rapid, and sustained movement to subdue the outbreak. Personnel, organization, equipment, and knowledge of all that relates to the behavior and control of fire summarizes the principal requirements for efficient performance in these various activities. Each represents a definite field of effort for improvement on the part of the Forest Service. To the extent possible with present funds the personnel is being enlarged and given special training for fire work; the organization for that work is being searchingly studied and steadily improved; new equipment is being developed, tested, and introduced—for example, tractors and other power machinery for constructing fire lines, and enlarged use of pumps in fire fighting—and special fire studies are being prosecuted to obtain through research better means of control. The drive for strengthening the mechanism of protection and for better performance in fire control is always on and will continue to be pressed energetically in every direction that holds out a promise of worth-while results.

Mention was made in last year's report of the establishment, by the chief coordinator of the Bureau of the Budget, of a protection board comprising representatives of the four Federal bureaus having extensive areas of forest lands to administer—that is, the Forest Service, the National Park Service, the Bureau of Indian Affairs, and the General Land Office—and also of the Bureau of Biological Survey and the Weather Bureau. This board, enlarged to include also representatives of the Bureaus of Entomology and Plant Industry, now embraces in its field protection against insects and tree diseases as well as against fire. It is making distinct progress in strengthening the Federal provision for controlling fires on forest lands of the United States, through better coordination of the efforts of the bureaus administering such lands and through the interchange of ideas and information. The most important step of the year to this end was the creation of regional boards which bring together the field men having in charge the work of actual protection. Joint use of purchasing facilities and of training-camp instruction are examples of the opportunities taken advantage of. In general, the protection board has

become an agency of great potential usefulness.

When the weather is favorable to fire control, national-forest organizations have breathing spells in which to catch up on other work. Broadly speaking, both 1927 and 1928 were relatively favorable years. Consequently the construction of telephone lines and of such structures as cabins for fire guards and lookout men could be carried on when rains made it safe for men to leave for a few days at a time the posts they must occupy day and night if conditions are threatening. Opportunities of this sort are very welcome, for the insufficiency of improvements is one of the weakest points in national forest protection. A recently completed survey of the requirements for fire control showed 12,066 miles of telephone line urgently needed, including replacements. Of the present lookout towers 73 need replacing, and 205 new ones are required.

To discover fires while small is essential. The lookout men are the eyes of the fire organization. When mountain peaks command a satisfactory view they take the place of towers; but these peaks are often so windy and cold that without shelter men can not stay on them continuously. Many-windowed cabins placed where the view is best are therefore required. There are now 359 such lookout cabins; 314 more are critically needed.

Similarly, 76 dilapidated cabins for fire guards call for replacement, and 588 new cabins should be built in locations where fire guards are now uneconomically sheltered by tents or are unprovided for. Upon the proper placing of guards depends the promptness with which fires can be reached after they are discovered and reported by the lookout men. Barns for horses and mules employed in protection are needed to the number of 227 new ones and 20 replacements.

Fire breaks are an investment which pays good dividends in reduction of fire losses, and should be constructed in many places. A special appropriation provides for their construction in cooperation with local agencies in southern California, deeply concerned for the protection of the watersheds of that region because of its high value to them. It has been impossible to consider constructing fire breaks elsewhere, but a need for 301 miles at particularly critical locations has been definitely recognized.

Other requirements include storehouses for equipment and food, water development, simple sanitary facilities, and pastures. Cut to the minimum, the estimates of urgent needs for protection improvements total \$1,779,206, exclusive of developments needed at headquarter ranger stations and public camp grounds. In many cases the improvements of the latter kinds also are chiefly necessary in the interest of fire control. The total needs for improvement construction amount to \$2,969,387, exclusive of range and camp-ground improvements.

The need for range improvements is discussed elsewhere. The appropriation item for improvements (other than camp-ground improvements, which are covered by a special item) in the fiscal year 1928 was \$526,900, and for the fiscal year 1929 is \$587,900. An allotment of \$30,000 for each year to range improvements and deductions for certain local improvements specified in the appropriation act reduced the general fund to \$394,900 for 1928 and to \$421,900 for 1929. To maintain existing improvements now requires about \$322,000 annually.

On the other hand, the improvement funds are supplemented by the use of the time of guards and rangers whenever favorable fire conditions permit. Such contributed time in the fiscal year 1928 theoretically augmented the improvement funds by \$331,799. In results, however, the value of the contributed time was much less, since men employed primarily for fire duty but switched for a few days at a time to such improvement work as happens to be within reach are used at a decided disadvantage, from the standpoint solely of the improvement work.

Much more advantageous use could be made of contributed time if it were possible to have telephone wire, lumber, and other materials more commonly on hand. Efforts to plan closely for utilizing spare time of the protection force are often nullified for lack of money to purchase and transport such materials.

RADIO EXPERIMENTS UNDER WAY

Friends of forest protection often wonder why radio has not been utilized as a means of maintaining the communication so necessary for successful fire control. Shortly after the close of the World War the Forest Service experimented with the radio equipment then available. Those early tests were discouraging, but with

the need for communication so urgent, further trial seemed obligatory.

Probably very little of the present 33,165 miles of Forest Service telephone line, constructed where other lines do not now exist, or of the over 7,000 miles of new line already scheduled as definitely needed, can ever be replaced by radio. It is true that there are some long lines in remote regions which, although vital to fire control for a period of two or three months each year, could nevertheless theoretically be replaced by radio communication with attractive economy in cost. The main reason for seeking to develop radio communication, however, is not to do away with existing or proposed telephone lines, but to supplement them. Even the single-wire telephone lines normally used on the national forests cost from \$70 to \$90 per mile to construct. They can not be built as needed to keep constant touch with all the scattered and shifting crews of men at work building roads or on some other form of construction work deep in the forests during the fire season. Such crews must move their camps frequently as their work progresses. To a certain extent touch can be maintained with them by emergency lines of insulated small wire laid on the ground or hung on the limbs of trees, but even this is expensive and often is not feasible.

It would be a great help if each such crew could be supplied with radio equipment weighing perhaps 50 or 60 pounds through which touch could always be maintained with the forest headquarters. It would also be a great help if a forest officer on reaching a fire could report back whether he needs a force of men to aid him, and if so, how many.

As a rule when fires must be fought by an organized crew of some size, an emergency telephone line is laid from the nearest permanent telephone line to the fire. This, however, takes the time of men who are badly needed just then to prevent further spread of the fire. Since light radio equipment, both sending and receiving, is already on the market, it would seem that there should be no difficulty in providing for such needs. But the matter is by no means simple. Aside from such technical matters as the best wave length to use, the type of battery power which will give the greatest sending power with the lightest weight, and the height, length arrangement, and method of erecting antenna wires

to be set up for temporary use in the woods, there are difficulties due to the effect of topography on transmission of code and voice. Further, the transmission of radio energy is affected to an unknown extent by what is called absorption by trees.

When the Forest Service sought advice from technical authorities of the Federal Government on radio, it learned that no work has been done on which conclusions can be based as to whether radio transmission of code and voice is a practicable thing under the conditions obtaining on the national forests. It has become necessary therefore not to test radio apparatus in connection with fire control but to test the national forests for the use of radio. Experimental work is under way.

If this laborious task of determining the effect of topography and timber on communication by radio shows that with certain equipment and methods fairly reliable results can be obtained, the way is open to the use of this new scientific development as an important aid in forest protection. There is no expectation of developing radio equipment which will permit transmission of voice both ways between a permanent central station and moving camps in the woods. Doubtless communication from the woods to the permanent central station must be by telegraph, using some simplified code.

PROTECTION FROM INSECTS AND TREE DISEASES

Epidemics of tree-killing insects, especially bark beetles, are part of the history of all coniferous-forest regions, especially those in which the older trees have not yet been cut. The young timber and reproduction are seldom killed, but the death of the older and larger trees destroys in whole or in part the marketable timber and creates bad fire conditions. The loss of timber, both directly and indirectly, from insect epidemics is of serious proportions and public concern.

During the year the most serious insect epidemic conditions on the national forests were in Montana and California. In Montana an increasing epidemic in the lodgepole pine on the Beaverhead National Forest, scattered over about 100,000 acres, was fought to prevent the complete loss of the trees large enough to be used now for ties or mining timbers and to prevent the spread of the infestation toward the valuable stands on the national forests surrounding the Yellowstone National Park. The technical methods followed

in this work were those recommended by the Bureau of Entomology, which in this as in other projects gave its hearty cooperation. It is as yet too soon to determine the degree of success of the work, but it is known that the areas covered by the same methods in the spring of 1927 had a relatively light infestation in 1928. It will probably be necessary to continue to fight this epidemic for at least another year.

In California an outbreak of another species of bark beetle on the Modoc National Forest and on intermingled and surrounding patented lands has been extremely destructive. As much as half of the valuable old pine timber has been killed on some sections. As the year closed the national forest timber was being advertised for sale under a contract which requires the purchaser to log the infested trees on a total of 15,000 acres of private and United States lands before the beetles emerge in the spring of 1929. In this way it is hoped to check the infestation by the removal of large numbers of beetles in the logs and to salvage the infested trees before they deteriorate too greatly to make usable lumber.

An infestation in western yellow pine on a national forest in Colorado was fought for the second year. This epidemic appears to have been checked, and probably little, if any, work will have to be done on it in 1929. Relatively small projects in Arizona, Oregon, and western Montana, in each case in valuable timber, were also carried out, that in Oregon being in cooperation with the owners of intermingled and adjacent privately owned timberlands. An area close to the Crater Lake National Park was also worked over to supplement the efforts of the National Park Service in combatting an infestation chiefly within the park.

A steady drain on the timber resources of the national forests by insects in small infestations is very large in the aggregate but is apt to be overlooked in the attention necessarily given to the disastrous larger outbreaks. The finding and removal or treatment of small groups of infested trees is both a check on this drain and the best preventive of major outbreaks. In cooperation with the Bureau of Entomology the training of forest officers to recognize dangerous conditions and to take the necessary action is being pushed.

Disease control is a problem comparable in magnitude with that of insect control and presents even more

formidable aspects. The white-pine blister rust was found during the year for the first time in the national forests of northern Idaho. This disease passes part of its life on the leaves of currants and gooseberries. Where these alternate hosts are abundant the commercial growing of any species of the five-needled pines is impossible. If there are no currants or gooseberries within about 1,500 feet there is little danger of infection to the pines. The spread of the disease into the western white-pine region of northern Idaho and western Montana makes necessary immediate decision whether to abandon the growing of the most valuable timber tree of the region or to control the disease by destroying the wild currants and gooseberries which are common in the region. The Forest Service believes it to be sound public policy to take the latter course, using the technical methods for destroying the currants and gooseberries which have been developed by the experimental work of the Bureau of Plant Industry and adopting each improvement in those methods as it is found and tested. No other action would be consistent with the purpose of furnishing "a continuous supply of timber for the use and necessities of citizens of the United States."

About 1,500,000 acres of national-forest land in the western white-pine region will need protection against this disease. This includes only the areas on which white pine will be the most important tree in future crops of timber. A plan for destroying the wild currants in this area progressively during the next 20 years has been prepared. More rapid action may prove to be necessary. In either case the additional work can not be done with the resources now available.

Another imported disease, the chestnut blight, continues to spread in the national forests of the Appalachians. No effective means of combating this disease under forest conditions is known. It is not dependent on an alternate host, as is the white-pine blister rust. Excellent progress has been made in salvaging the chestnut of usable size on the national forests. On the Natural Bridge Forest most of the chestnut suitable for telephone poles, the most valuable form of product, has been sold and cut. Although the ground formerly occupied by chestnut will be covered by other species, especially oaks, the elimination of chestnut will reduce the rate of

growth in volume per acre materially and will force the closing of industries, such as some tannic-acid manufacturing, which have used its wood.

Larch canker, a new disease recently introduced into the United States by importation and similar in many ways to the chestnut blight, threatens if once firmly established to become by far the most serious source of forest destruction ever known in this country, since it kills not only larch but Douglas fir and, perhaps, western yellow pine. The stake is stupendous, and the most energetic measures of control should be inaugurated. The Forest Service views the situation with the utmost anxiety.

Old timber of any species is subject to attack by native rots or other diseases. The common occurrence of red rot in old stands of pine or Douglas fir is an example. The cutting of diseased trees is required by the contracts for the sale of national-forest timber, as a precaution against the spread of infection to the new crop. The effect is becoming evident with the increasing period of national-forest administration. In the Blacks Hills region of South Dakota, for example, the reduction of the log scale, to allow for rot, in the second cutting will be less than half of that in the first cutting. The aim is to grow stands of timber free from diseases which either kill the trees or reduce their usefulness, and the steady, gradual elimination of sources of infection is necessary for the accomplishment of that purpose.

TIMBER

The timber resources of the national forests must be handled under the best forestry methods consistent with present economic conditions, if they are to fit into their right place in the general timber economy of the United States. The national forests make the Federal Government far and away the largest timberland owner in the country. It should take the leadership in efficient forest management.

One of the basic purposes of the national forests as defined by Congress is "to furnish a continuous supply of timber for the use and necessities of citizens of the United States." Yet there is another important purpose for them to serve. They should, through sound forestry practice, demonstrate to the private owner the possibilities of management. Upon them silvicultural practices and sound principles of forest management can and should be developed on a scale large enough to

be practically applicable by the owners of extensive private tracts. They have therefore the dual rôle of producing timber to supply present and future needs, and of developing and demonstrating the best methods of forest management.

Some have maintained that the national-forest timber should be held for the future and no cutting should be allowed at the present time. Such a policy would be short-sighted. Obviously, in that case the national forests could not play any considerable part in the development of forestry in the United States. And besides, timber can not be stored indefinitely. Decay and the ravages of timber-destroying insects are sure to deplete mature and overmature stands. Virgin forests ordinarily do not increase in volume, since the natural loss balances growth. The mature stands which cover the larger portion of the national forests are in very many places not even holding their own but are actually going backwards. The remedy is systematic cutting so that new growth can start.

Yet this cutting must be so regulated as to assure a continuous supply. To harvest these virgin stands as fast as possible would in the long run produce more timber, but it would result in a suspension of cutting after the present supplies are gone until a new growth is large enough to be marketed. The cutting must therefore be extended over a long period. This enables the forests not only to yield for present consumption timber which otherwise would be largely wasted through decay but also to increase steadily their production through growth without interrupting their future yield at a time when it will be badly needed.

The cut of national-forest timber, although only about one-sixth of what it may be ultimately, has increased from 138,666,000 board-feet in 1906 to over 1,000,000,000 feet annually. The rate of increase could easily have been accelerated by offering timber without regard for the permanency of local industries and by offering timber at bargain rates. Neither has been done. The purpose has been and is to offer timber at fair appraised prices as the needs of users and the development of transportation make successive units of the forests ready for operations, and then to sell no more than can be supplied in the future as the timber is renewed by growth. At the present time less than

3 per cent of the lumber consumed annually in the United States is derived from national-forest stumpage.

To make the national forests of greatest value for the present and future timber supply of the United States they have been studied for many years. As opportunity arises they are being organized into a large number of timber farms, each managed under definite plans for permanent wood production. This involves also the stability of the industries manufacturing the timber and of the communities dependent on those industries.

Plans for the management of these timber farms are made as they are needed to guide operations on parts of the forests where transportation facilities make the cutting and removal of timber feasible. They give definite answers to such questions as what shall be the area unit from which a "continuous supply of timber" is to be obtained; how much timber can be cut from that area annually or by decades and still have the growth on the whole unit replace the amount cut; what conditions must govern the cutting in order to obtain the best crops of timber for future cutting; what bodies of overripe or deteriorating timber need cutting promptly; how the greatest aid can be given to local industrial and community stability through the provision of employment in woods work and of raw material for the manufacture of forest products; and, finally, what definite areas of timber are to be offered for sale during the next 10 or 20 years.

Under such plans the future availability of definite quantities of timber is assured, and business enterprises can depend upon it. Further, the administration of each area can be organized on a permanent basis, since the amount of timber to be cut during each year or other period is known. On the Harney National Forest in South Dakota, for example, the cutting and manufacturing of timber is the chief business of several small towns, each of which knows that the timber tributary to it is being cut no faster than it is being replaced, and therefore that it need not fear the fate of most sawmill towns of the past. Only some major disaster, such as a series of large forest fires or a great epidemic of tree-killing insects, will imperil the continuous output of timber from a national forest thoroughly organized under sound timber-management plans.

The preparation of these plans must be preceded by an inventory of the timber on the area and by studies of the growth rate of young timber stands in the region. Steady progress is being made in all the national-forest regions in getting these data and in making plans based on them. During the year about 30 plans in either preliminary or final form were prepared and approved by the Forester. A bulletin describing the preparation of timber-management plans and containing the text of four previously approved plans was published. The preparation of management plans for additional national-forest areas as they are needed and the systematic review and modification of existing plans as better data are obtained and as market or other conditions change, will be a continuing task through future years.

Timber sales are made in accordance with the provisions of these plans. The limiting of the output to the quantity that can be sustained not only leads to stability and permanence of industries and communities but also tends to prevent the overproduction of lumber and other products. The lumber industry has tended to be concentrated in regions or localities, each of which is stripped of its usable timber in turn. To an increasing extent, the

example of continuous yield from the national forests is inducing lumbermen to study their own holdings to see if they can not be managed on the same basis; sometimes in connection with adjacent national-forest areas. Thus, the national forests are fulfilling their objects both as timber-producing units and as demonstration areas for the production of timber in private ownership.

The cut and sales of national-forest timber in the calendar year 1927 are shown in Tables 8 to 10. During the year the lumber industry was suffering one of its periodic depressions. Many lumbermen shut down or operated only on a reduced scale. Such conditions are inevitably reflected in the cut of national-forest stumpage; and the volume fell off as compared with that in 1926. A following partial recovery in the lumber industry has brought up the cut for the fiscal year 1928 to practically the same as that for the fiscal year 1927; and the receipts from timber were actually greater by \$71,836.74, totaling \$3,325,079.24 during the fiscal year 1928. The sales business now assured makes it clear that the check in the growth of use of the timber resource was temporary, as were similar checks in previous times of depression such as 1915 and 1921.

TABLE 8.—Quantity and value of national-forest timber sold, calendar year 1927

State	Quantity sold			Value		
	Commercial sales	Cost sales	Total	Commercial sales	Cost sales	Total
	<i>Board feet</i>	<i>Board feet</i>	<i>Board feet</i>			
Alabama.....	201,000		201,000	\$423		\$423
Alaska.....	37,134,000		37,134,000	55,484		55,484
Arizona.....	11,960,000	356,000	12,316,000	23,672	\$352	24,024
Arkansas.....	4,944,000	232,000	5,176,000	31,681	232	31,913
California.....	67,952,000	1,538,000	69,490,000	172,088	1,030	173,118
Colorado.....	42,372,000	911,000	43,283,000	104,747	838	105,585
Florida.....	3,038,000		3,038,000	16,894		16,894
Idaho.....	62,547,000	4,420,000	66,967,000	150,361	4,088	154,449
Kentucky.....	23,000		23,000	268		268
Michigan.....	4,806,000		4,806,000	9,027		9,027
Minnesota.....	4,233,000		4,233,000	19,426		19,426
Montana.....	22,381,000	2,959,000	25,340,000	45,017	3,157	48,174
Nevada.....	1,222,000	233,000	1,455,000	1,339	191	1,530
New Hampshire.....	12,136,000		12,136,000	65,270		65,270
New Mexico.....	20,726,000	684,000	21,410,000	49,357	604	49,961
North Carolina.....	14,683,000		14,683,000	27,806		27,806
Oregon.....	36,105,000	2,434,000	38,539,000	103,878	1,684	105,562
Pennsylvania.....	143,000		143,000	964		964
South Dakota.....	29,059,000	358,000	29,417,000	99,918	395	100,313
Tennessee.....	14,250,000	101,000	14,351,000	17,285	115	17,400
Utah.....	3,997,000	999,000	4,996,000	7,423	1,064	8,487
Virginia.....	34,679,000	1,000	34,680,000	101,631	2	101,633
Washington.....	158,805,000	274,000	159,079,000	349,975	165	350,140
West Virginia.....	800,000	4,000	804,000	1,948	4	1,952
Wyoming.....	37,979,000	1,019,000	38,998,000	106,500	964	107,464
Total, 1927.....	626,175,000	16,523,000	642,698,000	1,562,382	14,885	¹ 1,577,267
Total, 1926.....	1,471,191,000	18,181,000	1,489,372,000	4,062,387	16,525	² 4,078,912

¹ In addition, minor products not convertible into board feet were sold, value \$59,368.

² In addition, minor products not convertible into board feet were sold, value \$19,655.

TABLE 9.—Quantity and value of national-forest timber cut under sales, calendar year 1927

State	Quantity cut			Value		
	Commer- cial sales	Cost sales	Total	Commer- cial sales	Cost sales	Total
	<i>Board feet</i>	<i>Board feet</i>	<i>Board feet</i>			
Alabama.....	227, 000		227, 000	\$458		\$458
Alaska.....	55, 293, 000		55, 293, 000	92, 471		92, 471
Arizona.....	67, 661, 000	337, 000	67, 998, 000	182, 991	\$363	183, 354
Arkansas.....	6, 119, 000	233, 000	6, 352, 000	39, 274	233	39, 507
California.....	272, 922, 000	1, 615, 000	274, 537, 000	332, 189	1, 045	833, 234
Colorado.....	35, 917, 000	539, 000	36, 456, 000	99, 649	568	100, 217
Florida.....	1, 963, 000		1, 963, 000	9, 208		9, 208
Idaho.....	119, 245, 000	4, 584, 000	123, 829, 000	439, 600	4, 205	443, 805
Kentucky.....	8, 000		8, 000	79		79
Michigan.....	2, 077, 000		2, 077, 000	3, 494		3, 494
Minnesota.....	10, 454, 000		10, 454, 000	45, 847		45, 847
Montana.....	21, 653, 000	3, 102, 000	24, 755, 000	44, 165	3, 196	47, 361
Nevada.....	956, 000	186, 000	1, 142, 000	1, 239	185	1, 424
New Hampshire.....	5, 705, 000		5, 705, 000	28, 347		28, 347
New Mexico.....	13, 310, 000	679, 000	13, 989, 000	31, 287	532	31, 819
North Carolina.....	11, 056, 000		11, 056, 000	31, 027		31, 027
Oregon.....	167, 524, 000	2, 241, 000	169, 765, 000	461, 254	1, 434	462, 688
Pennsylvania.....	120, 000		120, 000	894		894
South Dakota.....	23, 075, 000	372, 000	23, 447, 000	80, 316	445	80, 761
Tennessee.....	12, 338, 000	74, 000	12, 412, 000	17, 423	82	17, 505
Utah.....	5, 216, 000	976, 000	6, 192, 000	9, 530	952	10, 482
Virginia.....	11, 807, 000	2, 000	11, 809, 000	30, 952	4	30, 956
Washington.....	201, 334, 000	195, 000	201, 529, 000	415, 656	113	415, 769
West Virginia.....	392, 000	4, 000	396, 000	1, 485	4	1, 489
Wyoming.....	29, 061, 000	1, 049, 000	30, 110, 000	70, 361	916	71, 277
Total, 1927.....	1, 075, 433, 000	16, 188, 000	1, 091, 621, 000	2, 969, 196	14, 277	¹ 2, 983, 473
Total, 1926.....	1, 158, 450, 000	16, 823, 000	1, 175, 273, 000	3, 441, 137	15, 024	² 3, 456, 161

¹ In addition, minor products not convertible into board feet were cut, value \$8,484.² In addition, minor products not convertible into board feet were cut, value \$9,526.

TABLE 10.—Number of national-forest timber sales classified according to amounts of sale, calendar year 1927

State	\$500 or under, com- mercial sales	\$500 or under, cost sales	Total	\$501 to \$1,000	\$1,001 to \$5,000	Over \$5,000	Total
Alabama.....	39		39				39
Alaska.....	196		196	16	8	2	222
Arizona.....	922	219	1, 141	2	5		1, 148
Arkansas.....	66	95	161			2	163
California.....	443	318	761	2	10	9	782
Colorado.....	579	146	725	7	11	5	748
Florida.....	97		97			1	98
Idaho.....	870	1, 364	2, 234	3	14	6	2, 257
Kentucky.....	12		12				12
Michigan.....	48		48		2		50
Minnesota.....	148		148		2	1	151
Montana.....	616	859	1, 475	7	4		1, 486
Nevada.....	99	97	196				196
New Hampshire.....	157		157	7	5	2	171
New Mexico.....	810	379	1, 189	4	12		1, 205
North Carolina.....	290		290	1	3		294
Oregon.....	416	471	887	1	3	8	899
Pennsylvania.....	7		7				7
South Dakota.....	261	76	337	2	9	5	353
Tennessee.....	272	69	341	3	3		347
Utah.....	230	599	829				829
Virginia.....	420	1	421		3	1	425
Washington.....	176	60	236	2	10	6	254
West Virginia.....	10	3	13				13
Wyoming.....	278	214	492	3	1	3	499
Total, 1927.....	7, 462	4, 970	12, 432	60	105	51	12, 648
Total, 1926.....	7, 528	5, 369	12, 897	135	109	58	13, 199

PLANTING

Planting is a necessary step in keeping forest land productive wherever past fires or other destructive agencies have denuded the land to such an extent that the timber will not reproduce naturally. The national forests include over 2,100,000 acres which should be growing timber but are not doing so. The planting of forests on them represents an urgently needed addition to the future timber supply of the Nation. Before it could be undertaken in any region on an adequate scale, careful tests and experiments in the production of small trees in nurseries and in planting methods had to be carried out, and the most effective and economical forms of organization of the work had to be devised and tested. In a number of regions, particularly in the western white-pine region of northern Idaho and western Montana, in the Lake States, in the sand hills of Nebraska, in the mountains of Colorado, in the Douglas fir region of western Washington and Oregon, and recently in the northern Appalachian Mountains, the technic of planting has been worked out. A beginning of the same process has been made in California.

Hitherto it has been possible to plant only from 7,000 to 12,000 acres annually. For economy the work has been concentrated in a few places; on other projects of almost equal urgency nothing has been done.

On the Michigan National Forest planting costs only about \$4 per acre—less than on any other forest. This low cost is due to the methods developed by careful study and tests of the local soils, species, and climatic conditions. The work has been done almost exclusively on the portion of the national forest in the Lower Peninsula, where about 20,000 acres have been planted and about 5,000 acres is added annually. On the portion of the forest in the Upper Peninsula, where the need is almost as great, it has been possible to plant only a few hundred acres.

An increase in the appropriation for planting from \$131,700 for the fiscal year 1927 to \$150,000 for the fiscal year 1928 made possible the starting of planting work on more than an experimental scale in the Appalachian region. A nursery has been established on the Monongahela Forest in West Virginia, and when the trees grown in it are ready for planting about 1,000 acres of the denuded burns on that forest will be reforested an-

nually. Small increases in the scale of planting in the Lake States were also made possible. The further increase in funds for the fiscal year 1929 will enable work to be undertaken on important projects on municipal watersheds in Colorado and Wyoming, on highly productive pine-land burns in California, and on several small projects in the eastern forests. An increase in the scale of work in the Lake States is also planned. Further increases in the scale of planting are needed to get progress commensurate with the size of the job and to bring the work into balance with other activities in national forest administration.

National-forest planting is done chiefly in the spring. Table 11, which gives the acreage planted in the calendar year 1927, does not, therefore, show the full effect of the increased appropriations for the fiscal year 1928, nor will that full effect appear until the new and enlarged nurseries have grown the additional numbers of small trees to a size suitable for field planting. The total of 12,847 acres planted or sown is, however, larger than in any other year of the past decade.

TABLE 11.—Planting and sowing on national forests by States, calendar year 1927

State	Area planted	Area sown	Total
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i> ■
Michigan.....	4,293.25	-----	4,293.25
Idaho.....	3,376.00	-----	3,376.00
Washington.....	1,310.00	-----	1,310.00
Colorado.....	1,251.69	-----	1,251.69
Nebraska.....	971.10	-----	971.10
Minnesota.....	545.00	-----	545.00
Oregon.....	510.00	-----	510.00
Montana.....	296.00	-----	296.00
West Virginia.....	152.15	-----	152.15
North Carolina.....	68.00	-----	68.00
Tennessee.....	.33	31.75	32.08
Kentucky.....	7.75	10.80	18.55
California.....	16.12	-----	16.12
Virginia.....	3.73	.82	4.55
Wyoming.....	2.12	-----	2.12
Total.....	12,803.24	43.37	12,846.61

RANGE

The western range livestock industry of to-day is very different from that of a quarter of a century ago. Unquestionably the changes that have taken place have been along economic lines. The new ways mean far better land use, more money for the stockmen, and more and better livestock products for the consumer. It is safe to say that even without the national

forests the general trend would have been in the same direction. But it would have been far slower, more irregular and uncertain, and at the cost of bitter struggles within the industry, with much individual and community suffering and loss.

RELATION OF NATIONAL-FOREST RANGES TO COMMUNITY WELFARE

At the opening of the twentieth century livestock production in the West was typically a public-lands industry. It had grown great on free range. It was a temporary use of vacant lands, pending the arrival of claimants entitled to make entry. It had already surrendered to the homesteader much of the country over which it had earlier held undisputed sway. This as well as its own growth had created fierce competition for use of the range, resulting in "range wars" and in overgrazing—which, of course, made matters still worse for the stockmen. The whole situation was precarious, chaotic, transitional, and in many ways economically unsound. It was also one which tended to retard rather than to facilitate settlement and community development.

To protect themselves many of the more powerful stockmen sought ways to establish range monopoly. On the other hand, nomadic flocks and herds from distant wintering and breeding grounds increasingly swept the high ranges. The "tramp stock man" moved from one region to another, pressing in ahead of the local residents in a scramble to get the feed. The home maker was ground between the upper and the nether millstone. To raise stock—the only product often-times which he could get to market—he had to have summer pasturage in the mountains; but there he found the feed eaten out. Very likely before he was prepared to begin the move the invading herds had come almost to his door. He was fortunate if his fences had sufficed to hold them out of his own meadows.

To-day, within or adjacent to almost every national-forest ranger district from Canada on the north to Mexico on the south, may be found thriving agricultural communities whose prosperity is mainly dependent upon the stable production of livestock. Climate, soil, and location combine to make this the most profitable form of agriculture. In many if not most cases, indeed, it is the only practicable form. Original settlement was greatly

influenced if not wholly induced by the extensive areas of nutritive native grasses adjoining the more productive valley lands.

The latter make possible developed ranches that serve as headquarters. Here in early days ample native hay could be harvested to supply winter needs, while abundant supplemental free range near by provided the means for a year-round economical livestock operation.

Overstocking of the range lands eventually taxed the agricultural valleys to the utmost to supply a deficiency in feed. This led to more intensive ranch management. Additional areas of agricultural land were broken up and seeded to more nutritious introduced species of grasses. There was a limit to which this could be done, and the further depletion of all range lands through the introduction of transient stock materially curtailed the number of stock operated from the valleys. Ranch incomes were greatly reduced, and the future of many once-productive ranches was most problematical. The fruit of years of labor and privation of pioneering settlers was at stake.

Unheralded, national-forest range administration sprang out of this chaos. The policy laid down by Secretary of Agriculture James Wilson on February 1, 1905, when he directed the Forest Service to "see to it that the water, wood, and forage of the reserves are conserved and wisely used for the benefit of the home builder first of all, upon whom depends the best permanent use of lands and resources alike," was a gleam of hope in an otherwise black foreground. That the policy has been carried out is attested by the present thriving condition of these mountain communities.

Natural conditions, of course, have played their part. An abundance of water for irrigation, an ample supply of timber for wood and building purposes, with the native grasses and other forage plants ripening at different altitudes to meet seasonal needs of ranch lands and livestock, awaited only the protection which national-forest administration has afforded. The point is that range regulation governed by economically sound principles and based on the authority of the Government as owner of the land to prescribe how it shall be used, together with the development by the Government of the technical knowledge essential for a right handling of the range resource, has made it possible to promote con-

ditions of community welfare that, in the absence of regulation, could have been attained only through a long and painful struggle for economic adjustment. And during that struggle both the productivity of the resource and the personal fortunes of almost numberless individuals and families would have suffered greatly. Land disposal could have brought no such favorable outcome; and community welfare imperatively demands, in the future as in the past, full retention by the Gov-

ernment of its present authority over the land. Vested rights must not be established, in any form.

The close relationship of national-forest range to community welfare is evidenced by the fact that over 4,500,000 acres of improved ranch land and 22,000,000 acres of grazing land are owned by the 27,000 permittees who grazed 1,459,823 cattle, horses, and swine, and 6,394,844 sheep and goats on the national forests during 1927, as shown in Table 12.

TABLE 12.—Grazing permits issued and number of stock grazed on the national forests, calendar year 1927

State	Cattle, horses, and swine				Sheep and goats		
	Permits issued	Stock grazed			Permits issued	Stock grazed	
		Cattle	Horses	Swine		Sheep	Goats
Alabama.....	7	40					
Arizona.....	1,176	208,559	2,631	268	117	340,191	1,796
Arkansas.....	33	654	6	26	1		12
California.....	1,947	155,116	6,428	179	366	433,970	2,990
Colorado.....	3,095	290,895	5,307		854	1,015,450	185
Florida.....	6	235		5	2	988	
Idaho.....	2,848	123,433	9,404		962	1,300,000	125
Montana.....	1,983	122,498	9,955		462	554,045	100
Nebraska.....	33	10,297	564				
Nevada.....	397	54,349	2,350		110	307,890	
New Hampshire.....	20	143	16				
New Jersey.....	1	56	3				
New Mexico.....	1,868	89,909	3,350	145	296	220,916	11,696
North Carolina.....	107	325	26	257	11	140	
Oklahoma.....	46	2,645	86				
Oregon.....	1,103	87,864	4,363	10	431	615,498	145
South Dakota.....	581	25,691	1,604		28	19,574	
Tennessee.....	27	226		39	1	20	
Utah.....	4,351	115,492	4,621	45	2,027	754,898	997
Virginia.....	62	694	6		7	156	
Washington.....	396	10,492	726		135	162,084	
West Virginia.....	40	334	70	28	13	1,348	
Wyoming.....	744	103,245	4,113		306	649,670	
Total, 1927.....	20,871	1,403,192	55,629	1,002	6,129	6,376,838	18,046
Total, 1926.....	22,295	1,456,858	57,396	1,085	5,982	6,212,657	15,666

In comparison with 1926, 53,666 fewer cattle but 164,181 more sheep were grazed. There were 1,424 fewer cattle permittees and 147 more sheep permittees. These differences represent economic adjustments. An improved market for cattle led many owners to liquidate indebtedness, while changes taking place on the ranch properties and open range outside the national forests were largely responsible for the increase in sheep and decrease in cattle.

While no adequate data are available for other localities, it is believed the business in the national forests is far more stable than elsewhere in the range country and that the main problem confronting the Forest Service in the immediate future will be to prevent overexpansion and overstocking

RANGE-MANAGEMENT PLANS

Over 80,000,000 acres within the national forests supply the needs of permitted livestock. This resource is vital to the prosperity of many dependent communities which must have available a permanent and plentiful supply of forage for the season of the year when the local livestock can not be maintained on the ranches. Increased productiveness of the range benefits the community, while if overgrazed ranges necessitate reductions in numbers or in the period of use, the dependent ranch properties have their earning power curtailed proportionately.

The Forest Service system of management aims to meet the best needs (1) of the range itself, (2) of the

related timber, game, water, recreation, and other resources, and (3) of the dependent ranch property. Experience and investigations have shown clearly how the forage plants can be used without loss of range productiveness, and often with its increase. They have shown, too, that observing the needs of the range itself minimizes if it does not entirely eliminate damage to other resources. In other words, it is now generally recognized that good range management is good forest, game, and watershed management. What is best for the range, however, is not always in accord with the conceptions of the owners of livestock and dependent property. Conflict frequently occurs when the growing season of plants is alike on the range and the ranch properties. To reconcile such conflicts the Forest Service is developing, in cooperation with the users themselves, a plan of management for each allotment or range. The plan consists of a map, with explanatory written details. Each plan embodies the essentials of good range practice; i. e., the right class and number of stock for the right season of the year, properly distributed so as to prevent overgrazing of portions and to secure even utilization of the forage crop on the whole range.

It is generally recognized that range productiveness should be measured in terms of quality and quantity of meat and wool, not quality and quantity of forage merely. The production of meat and wool depends upon many factors over which the Forest Service has no control, but in which it is extremely interested. The Forest Service, therefore, encourages, through its contact with individuals and livestock associations, the adoption of better practices in all lines of livestock production. Class, breed, and care of livestock when not on forest ranges are of sufficient importance to merit the careful consideration of all progressive stockmen. "More feed, more care, and better livestock" is still a slogan which might be followed with profit to the industry. The increased interest and response of permittees in the development and application of better practices is notable. It is because of this that the Forest Service has been able to complete plans on 4,415 out of a total of 7,064 range allotments.

GRAZING FEES

Last year's report discussed the settlement of the grazing-fee controversy. In accordance with that set-

tlement a new schedule of fees went into effect on January 1, 1928. While stockmen generally do not want fees raised, it is believed they accept the new rate as fair compensation to the Government for use of a public resource. Only one appeal to the Secretary's office has been made. This appeal, however, affects grazing fees throughout one entire State and involves policy questions of far-reaching importance which will require careful study before a conclusion is reached.

RANGE CONDITIONS

The season of 1927 was on the whole a favorable one for the stockmen, though portions of Montana, Oregon, Washington, and California were over-dry throughout. Most of the Rocky Mountain and intermountain regions received a plentiful supply of precipitation. In the Southwest a rather light winter snowfall was followed by an abundance of early spring moisture. This brought on a good crop of annual forage plants throughout the southern part of the region; but on some of its northern forests the spring was cold and backward. Summer rains with favorable growing conditions left on the range more feed for winter use than has been the case for a number of years.

With both market and forage conditions improved, the industry experienced one of its most prosperous years. In some localities, however, complaint was made that the exceptionally rainy season and resultant rank growth of vegetation produced light lambs. Generally, the financial situation of livestock owners was materially strengthened. The delinquent grazing fees heretofore reported have been collected, except where stockmen have gone out of business.

LIVESTOCK ASSOCIATIONS

Livestock associations are now a part of the community life. It is through such organizations that common problems can be discussed and settled with mutual satisfaction and benefit. These associations are fostered and helped in every possible way in order that a better understanding may be had of the problems of the Forest Service and stockmen alike. Through the meetings of the associations and the advice of their advisory boards local forest officers are greatly aided in making administration harmonize closely with community wishes and welfare. In short, the administration of grazing on the national forests

assumes a greater degree of local self-government than is generally possible in the conduct of public business. In this instance, however, the business of the Government is the business of the stockmen, so far as the best use of forest range is concerned. While the Forest Service makes no effort to dictate the manner in which the stockman conducts that part of his business related to but not directly connected with supervision of the range, it helps progress by enforcing special rules adopted by the associations governing the number and breed of bulls, the purchase and distribution of salt, hiring range riders, etc. Through these special rules a marked improvement in breeds and handling of stock has been secured.

Cooperation exists with 735 officially recognized stock associations, and in 1927, 987 association meetings were attended by 1,164 forest officers and 13,336 stockmen.

LOSSES OF LIVESTOCK

Reducing livestock losses makes the national-forest ranges more productive. Poisonous plants not only cause heavy direct losses but also interfere seriously with proper range use. Small infested areas may prevent the full use of much larger areas. Often use must be postponed until the toxic properties of the plants have disappeared. That may close the range during the part of the grazing season when dependent ranch property most

needs it. Further, by the time that stock can be safely admitted the forage may have reached an unpalatable stage of development, so that an almost total loss of range use results.

To the close of the calendar year 1927 eradication work covered 11,399 acres and cost \$50,395, while 403,150 acres still need eradication work, the estimated cost of which would amount to \$1,781,923.

Losses from poisonous plants, especially from larkspur, seem to be greatly influenced by the character of the season. Why this is true can be settled only by more intensive investigation and experiment.

All kinds of losses except those from natural causes can be materially reduced through such means as poisonous-plant eradication, predatory-animal control, fencing bog holes, and fencing ranges to prevent unnecessary loss from drift. As a rule, national-forest ranges are free from contagious disease, and danger from this source is held to a minimum by the effective inspection work conducted by Federal and State agencies, with which the Forest Service cooperates fully. The total number of stock lost in the calendar year 1927 was 145,746, valued at \$2,001,990—a decrease from the losses in 1926 of 10,232 animals, valued at \$152,540. Table 13 gives further details. Of the losses due to poisonous plants, larkspur accounted for 70 per cent of the number of animals and 63 per cent of the value.

TABLE 13.—*Livestock losses on national forests, 1927*

District	From poisonous plants		From predatory animals, disease, and other causes		Total	
	Cattle and horses	Sheep and goats	Cattle and horses	Sheep and goats	Cattle and horses	Sheep and goats
1.....	274	2,121	801	13,017	1,075	15,138
2.....	2,326	3,582	1,989	22,540	4,315	26,122
3.....	531	1,171	6,811	3,393	7,342	4,564
4.....	1,876	9,790	1,655	43,228	3,531	53,018
5.....	449	1,874	801	9,027	1,250	10,901
6.....	130	2,880	508	14,972	638	17,852
Total.....	5,586	21,418	12,565	106,177	18,151	127,595

RANGE IMPROVEMENTS

Stockmen have cooperated extensively in the construction of trails, drift, division, and boundary fences, bridges, corrals, and pastures, in the improvement of watering facilities, and in the eradication of poisonous

plants. Without these improvements, control of range use would be difficult and in some cases impossible, and local overstocking, with resultant range depletion, would be inevitable. Fortunately the stockmen have recognized this, and the greater part of the improvements have been constructed at

their expense. An urgent need exists, however, for additional improvements. With the increased grazing fees now in effect range users are looking to the Government to do more. An obligation exists which must be met if present cooperative relationships are to be maintained. Aside from the obligation, range improvements are good business, for they will increase revenues by bettering the range, and will cut down administrative expenses. From 7 to 10 years should suffice to retire the cost of range improvements.

The Forest Service has allotted funds to the limit of the resources which it can consistently make available from present appropriations. Some progress is being made on the more important projects. For example: Lack of control of livestock at the boundary of the forests and during the grazing season has resulted in serious damage to timber reproduction in northern Arizona. Plans were developed in 1925 for the construction of necessary fences and watering places and the introduction of improved methods of handling the stock. This plan

was alternative to a large reduction in the numbers of stock on some ranges and the total elimination of grazing from others. The changes have been almost completed, with marked benefit to the range and to timber reproduction.

Other important projects are waiting. For example, in Oregon range for 14,000 head of sheep is now idle on the Malheur National Forest. The heavy growth of herbaceous vegetation greatly increases the fire hazard to which a large body of virgin timber stands exposed. This condition has been the chief reason for large fires. The hazard could be greatly reduced by grazing, but for this watering facilities must be created. Their estimated cost is \$9,000. Lacking funds available for this purpose, the Forest Service is having to spend approximately \$14,000 a year in fighting the fires, while valuable and important timber goes up in smoke and the Federal Treasury loses some \$2,000 a year in grazing fees that would probably be forthcoming could water be provided.

Table 14 indicates the present status and variety of projects.

TABLE 14.—Range improvements constructed on national forests to December 31, 1927, and additional improvements needed

	District 1	District 2	District 3	District 4	District 5	District 6 ¹	Total
Boundary and drift fences.....miles..	409	773	4,669	852	1,103	762	8,568
Water development.....number..	266	752	38	726	448	352	2,582
Driveways.....miles..	801	1,228	-----	263	44	466	2,802
Bridges.....number..	18	21	17	17	7	15	95
Trails.....miles..	-----	-----	-----	218	26	52	296
Corrals.....number..	67	64	30	101	184	131	577
Cabins.....do.....	35	-----	-----	3	191	77	306
Pastures.....do.....	14	-----	-----	8	415	1	438
Poison eradication.....acres..	106	7,176	230	3,193	628	76	11,409
Salt troughs.....number..	2	-----	-----	25	1,492	1,400	2,919
Cost to stockmen.....dollars..	86,019	100,626	2,089,092	172,902	314,729	142,183	2,905,551
Cost to Government.....do.....	144,485	112,253	128,278	126,557	45,846	46,298	603,717
Total cost.....do.....	230,504	212,879	2,217,370	299,459	360,575	188,481	3,509,268

RANGE IMPROVEMENTS NEEDED

Boundary and drift fence.....miles..	306	244	4,455	549	324	578	6,456
Water development.....number..	290	165	356	603	629	565	2,608
Driveways.....miles..	120	1	-----	25	-----	99	245
Bridges.....number..	34	1	-----	8	3	14	60
Trails.....miles..	19	-----	79	129	20	-----	247
Corrals.....number..	4	15	128	21	4	27	199
Cabins.....do.....	17	-----	-----	13	3	22	55
Pastures.....do.....	-----	-----	-----	15	42	-----	57
Poison eradication.....acres..	4,240	112,428	248,111	35,089	2,450	809	403,127
Salt troughs.....number..	249	-----	-----	-----	1,794	1,521	3,564
Cost to stockmen.....dollars..	585	34,016	251,932	103,304	46,390	73,602	509,829
Cost to Government.....do.....	73,892	48,966	311,817	258,733	80,971	155,083	929,462
Total cost.....do.....	74,477	82,982	563,749	362,037	127,361	228,685	1,439,291

¹ Also 24,400 acres of squirrel eradication in district 6. 24,600 acres need work.

RANGE-DESTROYING RODENTS

Prairie dogs, squirrels, gophers, and other range-destroying rodents infest about 7,000,000 acres of national-forest land. They destroy forage enough annually to support 25,000 cattle five months. The loss in carrying capacity varies from 5 to 95 per cent. While it is small in comparison with the total grazing use, it represents a loss to the Government of \$25,000 a year in grazing fees, besides the loss to the livestock industry. Further, unless controlled, infestation is progressive and affects an ever-increasing area.

The problem is made much more difficult by the fact that private and public lands outside the forests are also infested. It must be attacked in a systematic manner. Private land-owners and State and county authorities are cooperating with the Bureau of Biological Survey on areas outside the forest. Such work will prove of little benefit unless adjoining areas on the national forest are controlled at the same time. The Forest Service has cooperated with other owners of land and the Bureau of Biological Survey to the limit of its resources, and some of the worst-infested areas on the national forests have been effectively cleaned up. Much credit is due to the expert knowledge and leadership of the Biological Survey in this work. Nevertheless, at present the control is apparently no more than keeping pace with the natural increase. The problem calls for substantially increased provision for this work on the national forests.

TRESPASSING LIVESTOCK

Another loss in forage and revenue is occasioned by livestock grazing without permit or control. Regulatory measures are applicable only to stock that is valuable and can be identified. The main difficulty is with horses of practically no value, often unbranded or abandoned. The national-forest ranges are supporting over 20,000 such animals. Their presence often results in overgrazing and necessitates reducing the number of livestock for which fees are paid. About \$20,000 annually is thus lost to the Treasury. Further, good range administration is interfered with. Roaming at will and scattered over large areas, these wild horses make it impossible to regulate properly the numbers of stock on the ranges. They can not be handled un-

der ordinary methods; they consume the salt placed on the range by permittees for their domestic stock and make more difficult and expensive the upkeep of fences and other improvements; and they cause reluctance on the part of permittees who comply with all regulations to continue paying fees for grazing their stock while stock not under permit are consuming feed that their own animals badly need.

In 1925 a regulation was promulgated authorizing local forest officers to advertise and impound stock found in trespass and to sell any horses not redeemed by the owners. Over 9,000 animals have been handled under the regulation, at an average cost of over \$3 per head. The work is of necessity expensive. Some \$11,000 received for redeemed stock was used for reimbursement of the expenditures, but this has now been held illegal, and after July 1 such receipts must be covered into the Treasury as "miscellaneous receipts, Forest Service." This ruling will greatly retard the work.

RECREATION AND GAME

The number of people visiting the national forests for recreation increased 8.2 per cent over the number in 1926. Special-use permittees and their guests increased 19.7 per cent, hotel and resort guests 2.4 per cent, picnickers 9.2 per cent, and transient motorists 11.8 per cent, while campers decreased 10.3 per cent.

During the year 156 camp grounds were improved in whole or in part; 919 camp grounds now have some improvements, as compared with the more than 1,500 camp grounds now being used heavily by the public. The expenditures for this purpose were \$42,517. The total cost of the improvements to date has been \$238,013, of which \$44,899 has been contributed in cash, material, or labor by private or public cooperators.

The study of the so-called "wilderness areas" or areas believed to be most useful if retained in a condition of relative undevelopment, continued throughout the year, and in one district was completed. It is not proposed unduly to curtail timber cutting, grazing, water development, mining, or other forms of economic utilization within such areas, but rather to guard against their unnecessary invasion by roads, resorts, summer-home communities, or other forms of use incompati-

ble with the public enjoyment of their major values.

During the year a special committee was appointed by the Secretary of Agriculture to make a study of the Mount Hood region in Oregon. This was because of local protests against a decision of the Forester refusing to grant a permit for the construction of a cableway to the summit. The findings of this committee will be of great value in determining whether such features of development will be compatible with the best use of the area by the public. In addition to specific recommendations for the Mount Hood area, the committee has been asked to submit recommendations regarding the proper forms of use and development within other similar areas in the State of Oregon, and in other States.

Studies and observations of wild life on the national forests were continued. Plans of administration are being developed as rapidly as the problems involved are ascertained and personnel and funds will permit. The major problems concern (1) methods of restocking or increasing game, (2) reliable game estimates, (3) reliable estimates of the game-carrying capacity of each forest, and (4) methods of holding the number of game animals in balance with carrying capacities.

It was found early in the administration of national forests that game animals have wonderful recuperative powers. Where they had not been completely exterminated adequate protection produced satisfactory results. Elsewhere restocking proved feasible. In either case, however, absolute protection proved a necessity.

Game refuges or sanctuaries brought about rapid increases and the restocking of adjoining areas. When, however, ruminant game animals reach the point of fully stocking the refuge and the drift from the area is inadequate to take care of the further increase, overstocking occurs, with resultant overgrazing and damage to timber and range. This has been exemplified on the Grand Canyon Game Preserve in Arizona and on certain elk ranges of the Lewis and

Clark, Absaroka, and Teton National Forests.

The national forests embrace both Federal and State refuges. The Forest Service is endeavoring to work out constructive management plans on Federal refuges and is actively cooperating in the creation and protection of State refuges. Over 19,000,000 acres of national-forest lands are included within refuges of the latter class, and about 10,000,000 acres of the total are grazed by domestic livestock. The dual use of such areas does not in itself present a particularly difficult problem. The numbers of domestic animals can be so regulated that ample feed is provided for game, up to a certain point. Fully 60 per cent of the carrying capacity of the 10,000,000 acres under dual use is reserved for game animals. Similarly, within the 1,268,000 acres of Federal game refuges included in the national forests, domestic stock consume only a small portion of the available forage. The fact that the feed requirements and habits of the different classes of animals are not alike makes it possible to graze all classes on the same range without material conflict, and without overgrazing so long as the numbers of each class do not exceed the capacity of the range to grow the forage species respectively preferred.

The determination, however, of a safe game-carrying capacity for ranges of widely varying conditions is not easy. For domestic livestock, experiments, investigations, and experience have developed reliable methods of determining this, but they can not be applied to game. Resort is therefore made to the method of trial and test, with an ample margin of safety. Obviously, the first necessity is to be able to determine with reasonable accuracy the number and species of game animals. For this various methods are used, some of which are wholly observational. As a working basis, however, it is believed the estimates shown in Table 15 are fairly reliable and will serve the purpose until more intensive conditions prevail and better methods have been developed.

TABLE 15.—*Number of big-game animals and beaver on national forests*

[Estimates as of December 31, 1927]

State	Antelope	Bear		Caribou	Deer	Elk	Moose	Mountain goats	Mountain sheep	Beaver
		Black or brown	Grizzly ¹							
Alaska.....		2 6,100	2,500	20	59,300	9	2,055	9,500	2,006	1,500
Alabama.....					125					
Arizona.....	2,157	595	20		59,009	841			262	93
Arkansas.....					1,450					
California.....	612	10,303			238,645	126			685	375
Colorado.....	114	2,641	19		27,757	8,519			3,835	43,905
Florida.....		25			650					
Idaho.....	2,065	5,728	142	10	57,613	7,965	639	3,246	1,403	15,747
Michigan.....		31			225					
Minnesota.....		1,385		3	7,300		1,850			5,792
Montana.....	976	5,433	433		52,368	10,927	1,168	4,005	1,880	17,111
Nebraska.....					50					2
New Hampshire.....		700			3,000		3			2
New Mexico.....	1,047	964	21		35,831	135			200	1,140
Nevada.....	177				5,455				170	222
North Carolina.....		90			4,120	35				
Oklahoma.....	20	2			300	350				
Oregon.....	29	6,911	1		71,508	5,785			40	5,238
Pennsylvania.....		150			1,175	18				30
South Dakota.....	2				2,946	856				2,337
Tennessee.....		27			85					
Utah.....		435	13		32,147	2,090			177	5,704
Virginia.....		450			48	75				
Washington.....		7,130	98	2	27,668	9,712	2	2,583	10	8,799
West Virginia.....		200			20					
Wyoming.....	466	1,717	133		11,791	26,736	2,233		2,583	9,030
Total.....	7,665	51,017	3,380	35	700,586	74,179	7,950	19,334	13,251	117,027

¹ Including Alaska brown bear.² Black bear only.

Only with regard to deer and elk are acute problems of game management faced that relate to holding in due balance the number of animals and the carrying capacity of the land. In spite of liberal open seasons there is everywhere a steady increase in deer, amounting to about 5 per cent annually. About 10 per cent is reported as being taken by hunters each season. As in past seasons, there appear to have been about three or four hunters for each deer killed. Nevertheless, the increase of deer in certain localities is raising a definite question as to the permanent adequacy of the food supply and as to means of regulating the number of animals and utilizing the increase to best advantage.

The problem of the Kaibab herd in northern Arizona is still unsolved. The situation is far from satisfactory. The number of deer far exceeds the number which the available feeding grounds can maintain, but the State of Arizona objects to a reduction of the number by raising the bag limit or by employing Government hunters for the purpose, with such disposition of the meat as may be possible. The

herd, which now contains approximately 28,000 head, is not holding its own. For two winters in succession a large part of the fawns born the previous year have died. These are both uneconomic and inhuman conditions. The authority of the Secretary of Agriculture to apply a remedy was affirmed by the Federal district court, but an appeal by the State is to be determined by the Supreme Court of the United States.

Elk have everywhere made excellent increases with good calf crops and low winter losses. Some of the herds are approaching the point above which further increases are fraught with danger. During the 1927 hunting season hunters killed about 1,000 of the Jackson Hole herd. This is about the usual number. Approximately 1,500 of the Yellowstone or Park herd were killed—not enough to offset the increase. The history of both these herds shows that whenever they rise, as at present, above 20,000 severe winter losses are only a matter of time.

The plants of elk elsewhere are all prospering. Some States very wisely have established open seasons to keep

the number down to the limit of the available range.

The number of antelope reported in Table 15 is about 10 per cent greater than last year. While the herds not in captivity are increasing, for reasons not yet clear antelope do not appear to thrive under fence. The little herd on the Wichita Game Preserve in Oklahoma has not prospered during the last four years, in spite of every possible attention.

Black and brown bear show about a 10 per cent increase over 1926, due possibly to closer estimates. Extending the protection of the game laws to these animals has contributed greatly to their increase.

In Table 15 the giant Alaska brown bear is classified with the grizzly. A special study of this bear made by forest officers in Alaska last year afforded a closer estimate of their number, and this caused a heavy decrease in the number reported. Outside of Alaska only 880 are listed, of which nearly 50 per cent are in Montana. The record shows not a single grizzly in any national forest in California—a State in which these animals were once numerous. The buffalo was never so near extinction as is the grizzly to-day.

Mountain goats and mountain sheep made small increases, but on most of the national forests moose are seemingly on the decline. Beaver continue to increase in all parts of the West. Their value to the irrigationists of the Intermountain States has been well established, while the income from pelts taken from surplus animals promises to be a permanent source of income to State game funds.

For several years the scarcity of grouse throughout the mountains of the West has been ascribed to trampling of the nests by grazing sheep. For the last two years forest officers have been taking notes on this matter. Reports for both seasons indicate that, generally speaking, the eggs of grouse are laid and hatched and the young have left the nests before the sheep reach the nesting grounds. The scarcity of grouse in any section may be due to disease or to raids upon the nests and young by small fur-bearing or predatory animals.

Forest officers referred to State officials for prosecution 496 game-law cases, which resulted in 199 convictions. Forest officers prosecuted 109 cases, which resulted in 94 convictions. Forest officers issued 7,230 State game licenses and examined 29,333.

WATER POWER

Of the water-power permits issued by this department prior to the passage of the Federal water power act, 272 were outstanding at the end of the fiscal year. For 185 rental charges were involved; the rest were free. The estimated average output at minimum discharge was 518,085 horsepower for the rental permits and 26,225 horsepower for the others. The corresponding lengths of transmission line were 942.46 and 155.40 miles, of which respectively 700.03 and 127.83 miles were on land within the national-forest boundaries.

Permits and licenses under supervision for and at the request of the Federal Power Commission at the close of the year numbered 257, as against 247 a year previously. The commission requested 48 field investigations and reports during the year, and 40 reports were made. Forest Service engineers also made several valuations and appraisals. The Federal Power Commission received 54 applications for projects in whole or in part on national-forest land. This represented approximately 62 per cent of the total number filed with the commission. Under authority granted by the Federal Power Commission the district foresters issued 6 permits for projects of 40-horsepower capacity or less and for periods not exceeding 10 years.

Upon the field engineers of the Forest Service falls the work of making inspections of design and construction of all dams erected within national forests under licenses issued by the Federal Power Commission. The Federal water power act gives the commission authority to make requirements in the interest of public safety or the proper development of the power resources of the Government's lands. This authority is exercised on the national forests through the Forest Service.

In addition to dams erected under license from the Federal Power Commission, dams may be erected in the national forests (1) under easements granted by several general acts of Congress, (2) under special grants made by Congress to specific agencies, and (3) under special-use permit from the Forest Service for uses or purposes other than water power or those specified in the laws granting easements and rights of way.

It is becoming increasingly important that these works be adequately supervised from an engineering stand-

point. The steady advance of settlement and accumulation of property increase the possibilities of destruction and demand factors of safety which might not have been justified under pioneer conditions. The Forest Service has ample authority to include in its permits for dam construction such requirements as to prior approval of designs and plans of construction as it may consider necessary to safeguard life and property, and this is being done.

Just how far the Forest Service can and should go in imposing such requirements when dams are constructed under special grants of Congress or under the general acts granting easements is another matter. The execution by applicants for easements of stipulations necessary to prevent the destruction of Government property or to safeguard other national-forest interests can, it seems certain, usually be required as a prerequisite to the approval of such easements unless special terms of the law exclude this course. Such protection of the interests of the Government might necessitate the requirement of advance approval of dam designs and plans of construction, and even provision for the permanent security of the dam. The right and duty of each State to provide such checks as are necessary to safeguard private property and human life is of course recognized. It does not, however, seem proper that the Forest Service should regard this as a matter outside its jurisdiction and with which it therefore should not be concerned in case the State fails to provide adequate checks. The Federal Government as a property owner should exercise the same precaution that any responsible private owner would wish to, by making sure that misuse of lands under its control does not unnecessarily jeopardize other property and human life.

The basis for coordinating the use of roads and transportation routes needed for power development with their use for other purposes incidental to the protection, administration, and utilization of the national forests has been worked out with the Federal Power Commission. In one case a power company endeavored to have the project license a railroad which would have controlled the only practicable outlet for over 6,000,000 feet of merchantable timber. This was ques-

tioned, and the railroad was included only on terms which will make its transportation facilities also available on equitable terms to the public and to timber purchasers from the Forest Service.

As to vehicle roads, the Federal Power Commission has agreed with the Forest Service that when built by licensees primarily for the project construction but needed for project operation and maintenance such roads should be open to public use as well as to use by the Forest Service. During the year a power company that had a very great investment in power structures and had expended large sums for road construction sought to be excepted from the regular policy because the amount of public use would be very great on certain roads, necessitating much larger expenditures for road maintenance and betterment than if traffic were restricted to the power company and the Forest Service.

This resulted in a modification of the policy so that hereafter the public is allowed a reasonable participation in the advantages accruing from pioneer development work, without permitting this to hamper the primary work of power development or to become a material burden on the licensee. Roads built in this country by the pioneer, whether an individual settler or a great mining company, have in the past always been open to the free use of everyone who wished to follow. The Forest Service is perpetuating this policy so far as it is fairly applicable to modern conditions.

ROADS AND TRAILS

Data on appropriations expenditures, balances, and accomplishments are shown in Tables 16 to 20.

Under instructions from the Bureau of the Budget, the program for the fiscal year was based on a total expenditure from the forest-highway and forest-road development funds of a sum not to exceed \$7,500,000. This represented a marked reduction from the amount expended the preceding year. Every precaution was taken to keep the expenditures within the limit set, and it is probable that some portion would have been unexpended if weather conditions last spring had not permitted contractors to begin work earlier than was expected. The actual expenditures were \$7,533,044, an overrun of approximately 0.4 per cent.

TABLE 16.—*Classification of mileage in forest road and trail system and expenditures required to complete system to satisfactory standard*

Class	Total	Satisfactory standard	Unsatisfactory standard	Nonexisting	Expenditures required to complete
	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>	
Forest highways.....	15,272	5,680	8,387	1,205	\$151,698,893
Forest development roads.....	39,285	14,917	13,154	11,214	50,380,292
Trails.....	128,347	83,615	10,036	34,696	5,840,322
Total.....					207,919,507

The expenditures for maintenance are increasing not only in amount but in percentage of the total, while the cooperative assistance has fallen off. In consequence less money is available for construction. Practically no cooperative assistance is to be expected in trail maintenance nor on a large percentage of the forest-development roads. On the forest highways it is hoped that as the most urgent needs for construction are met the States and counties will take on some of the maintenance costs now borne by the Federal Government. At present the situation is very serious in several States, since the funds remaining to the Government after financing the necessary maintenance fall far short of what is urgently required for construction and betterment work. The forest road and trail system comprises the roads and trails which, on the basis of present knowledge, will be needed within 10 years. On the basis of present costs, standards, appropriations, and maintenance expenditures, with no cooperative assistance completion of the system as it now stands is over 40 years away, to say nothing of the new needs that will arise in the interim.

During the winter the House Committee on Roads held extended hearings on proposed road legislation. A considerable period was given to bills legislatively authorizing appropriations for Federal-aid and forest roads for the fiscal years 1930 and 1931. Several of those testifying before the committee on these bills and another authorizing \$3,500,000 yearly for three years, to be expended for roads on reserved and unreserved public lands, stressed the need of greater progress on the main highways within the national forests and presented data showing that decidedly less progress is being made on such highways than on similar highways outside the forests.

Those testifying were primarily concerned with the roads on the 7 per

cent and State systems. An equally strong case can be presented for the county and community roads, especially those on the forest-development system. Statements have frequently been made of the importance of the system to the national forests, and of their service in reducing fire losses and fire-suppression costs. Over five years have elapsed since the work on these roads and trails was started. It is now clearly evident that their value has not been overstated.

Possibly the greatest single benefit to fire control has come from having under Forest Service supervision road and trail construction crews ready for instant service on fire suppression in regions of high fire risk. The crews are utilized full time for fire fighting when so needed, and at other times on construction and maintenance work. It has been estimated that to obtain the same measure of protective value without the present coordination between the road and trail work and the protective activities would require an additional protection appropriation of at least \$500,000 annually. Also, a large portion of the time of the added protective force would not be utilized. Scores of examples could be given of the specific value of roads and trails to national-forest protection and administration and to the utilization of the forest resources, particularly timber. In many cases the value received has already far exceeded the investment made in the roads and trails.

At its last session Congress authorized appropriations of \$7,500,000 for each of the fiscal years 1930 and 1931, under the provisions of section 23 of the Federal highway act. This amount is the same as that legislatively authorized for the past few years. For the fiscal year 1929, the appropriation under section 23 of the Federal highway act is \$7,500,000. A most important change was made in the legislative provision relative to incurring ob-

ligations against amounts unappropriated but subject to obligation. The Secretary of Agriculture is now mandated to obligate the entire \$7,500,000 authorization for the fiscal year 1929. Carrying out this mandate means that

the \$7,500,000 appropriation already made will be insufficient to make all necessary payments during the fiscal year. A supplemental appropriation of an amount which can not now be definitely determined will be required.

TABLE 17.—Construction, improvement, and maintenance of roads and trails from forest road appropriations and other Federal and cooperative funds, by States

State	Fiscal year 1928				Total to June 30, 1928		Expenditures to June 30, 1928		
	Constructed		Maintained		Constructed		Federal funds	Cooperative funds	Total funds
	Roads	Trails	Roads	Trails	Roads	Trails			
	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>	<i>Miles</i>			
Alabama.....	15.9		19.0		29.0		869,156.18	\$1,962.65	\$71,168.78
Alaska.....	10.6	51.7	175.0	108.9	197.4	336.8	3,410,814.28	279,789.45	3,690,603.73
Arizona.....	101.6	10.5	1,194.9	475.0	962.7	1,502.0	4,290,845.57	538,262.07	5,148,608.64
Arkansas.....	70.9	12.5	144.5	182.0	417.1	474.3	534,313.68	25,247.73	\$79,561.41
California.....	302.2	223.9	2,427.0	6,130.8	1,688.1	2,616.7	10,448,578.06	3,568,140.81	13,996,718.81
Colorado.....	95.1	754.4	700.4	8,294.1	1,164.2	4,104.6	5,450,354.22	\$16,584.56	5,466,938.78
Florida.....	28.0		152.9		183.6		267,833.74	196,811.14	464,644.88
Georgia.....	13.3		19.1	168.6	48.1	168.6	337,200.98	37,044.51	\$34,245.49
Idaho.....	100.6	1,321.8	1,702.9	9,762.6	1,776.2	8,847.9	10,813,612.65	1,488,787.27	12,302,699.90
Illinois.....							8.00		8.00
Kansas.....					3.4		2,111.51		2,111.51
Kentucky.....				8.0			578.49		578.49
Maine.....			5.3	40.8	5.3	40.8	29,573.28		29,573.28
Maryland.....									
Michigan.....	6.0		343.0		31.2		57,822.21	393.45	58,215.66
Minnesota.....	70.0	7.8	78.0	85.0	390.0	112.0	579,221.05	241,556.89	\$20,777.95
Montana.....	32.1	873.2	1,214.2	7,822.3	887.7	3,803.3	4,496,277.16	580,221.07	7,076,598.23
Nebraska.....			50.4		46.3		71,629.76	990.80	72,620.56
Nevada.....	5.1	16.0	378.3	377.5	428.1	776.5	1,119,127.29	143,846.65	1,263,473.94
New Hampshire.....		5.5	30.9	330.2	35.0	336.7	235,648.11	18,474.63	254,122.74
New Jersey.....			24.0				147.54		147.54
New Mexico.....	63.4	42.0	488.2	1,155.0	655.4	1,558.8	3,193,297.27	298,153.38	3,491,450.60
New York.....			22.0				77.32		77.32
North Carolina.....	4.0	56.0	168.5	568.3	175.3	694.3	576,238.47	55,942.45	632,180.92
North Dakota.....					1.0		57.75		57.75
Oklahoma.....			34.1	1.5	24.7	16.3	47,724.59	10,988.63	58,713.22
Oregon.....	857.6	1,473.9	3,539.6	8,337.0	2,468.6	4,692.7	9,905,460.29	5,446,622.75	15,352,083.07
Pennsylvania.....	4		75.0	10.0	42.4		58,959.08	1,005.00	54,958.08
Porto Rico.....	3.6			36.0	4.6	36.3	15,234.12	550.00	15,834.12
South Carolina.....			48.9		16.3	4.0	77,826.23	15,170.60	92,996.83
South Dakota.....	27.1	8.5	150.1	29.5	268.2	61.7	668,657.04	183,879.21	\$32,314.55
Tennessee.....	7.1	7.0	39.5	412.6	89.1	437.6	280,899.70	130,161.29	411,061.00
Utah.....	33.4	327.2	580.1	1,471.1	990.2	3,152.7	2,772,610.36	722,767.92	3,495,378.31
Virginia.....	12.5	16.0	92.6	498.6	124.1	698.1	444,139.54	86,740.41	530,879.95
Washington.....	103.0	941.3	868.5	5,214.0	963.9	3,143.5	6,273,413.45	1,477,726.22	7,751,139.67
West Virginia.....	6.6	16.5	38.7	77.0	49.3	265.0	123,873.26	3,823.68	127,696.97
Wyoming.....	58.7	296.0	593.3	3,221.3	929.6	2,004.5	3,517,861.91	969,920.01	4,487,781.92
Total.....	1,537.7	6,462.1	15,688.2	85,987.8	14,822.6	39,696.4	72,717,912.02	16,879,492.73	89,597,404.80

TABLE 18.—*Distribution among the States of the appropriations and apportionments for the fiscal year 1929*

State	10 per cent fund	Forest highway fund			Forest road-development fund			Total appropriated and authorized to be obligated
		Appropriated	Additional amount authorized to be obligated	Total	Appropriated	Additional amount authorized to be obligated	Total	
Alabama.....	\$121.50	\$1,665	\$2,55	\$4,216	\$7,070	\$4,862	\$11,932	\$17,155.50
Alaska.....	8,976.70	184,324	282,319	466,643	14,456	9,942	24,398	598,012.70
Arizona.....	31,763.99	112,583	172,438	285,021	80,800	55,571	136,371	513,010.99
Arkansas.....	2,885.83	15,097	23,122	38,219	24,400	16,781	41,181	90,310.83
California.....	136,020.85	265,236	406,247	671,483	261,332	179,735	441,067	1,389,581.85
Colorado.....	41,537.15	130,037	199,171	329,208	87,697	60,315	148,012	587,891.15
Florida.....	2,146.23	4,704	7,205	11,909	13,999	9,628	23,627	40,183.23
Georgia.....	1,062.94	2,884	4,418	7,302	11,210	7,709	18,919	28,817.94
Idaho.....	67,863.84	198,548	304,104	502,652	384,767	264,630	649,397	1,325,468.84
Illinois.....	230.23	151	232	383	-----	-----	-----	464.00
Kentucky.....	193.75	525	805	1,330	3,958	2,723	6,681	8,484.75
Maine.....	15.00	-----	-----	-----	-----	-----	-----	15.00
Maryland.....	888.62	1,364	2,088	3,452	965	663	1,628	6,692.62
Michigan.....	2,544.50	11,044	16,916	27,960	19,376	13,326	32,702	69,078.50
Minnesota.....	21,555.10	156,097	239,086	395,183	168,955	116,202	285,157	784,884.10
Montana.....	1,040.18	1,819	2,786	4,605	694	477	1,171	7,783.18
Nebraska.....	8,834.97	37,078	56,789	93,867	2,492	1,713	4,205	126,617.97
Nevada.....	2,638.82	7,008	10,733	17,741	13,031	8,962	21,993	46,097.82
New Hampshire.....	70.17	-----	-----	-----	-----	-----	-----	70.17
New Jersey.....	12,977.21	82,322	126,089	208,411	71,802	49,383	121,185	386,340.21
New Mexico.....	4.00	-----	-----	-----	-----	-----	-----	4.00
New York.....	2,426.73	4,917	7,530	12,447	20,603	14,170	34,773	52,259.73
North Carolina.....	697.74	817	1,252	2,069	203	139	342	3,543.74
Oklahoma.....	68,660.69	245,755	376,410	622,165	268,486	184,655	453,141	1,274,621.69
Oregon.....	1,173.56	2,703	4,139	6,842	3,710	2,552	6,262	15,713.56
Pennsylvania.....	-----	205	315	520	149	103	252	882.00
Porto Rico.....	455.39	907	1,388	2,295	3,083	2,120	5,203	8,434.39
South Carolina.....	12,515.44	15,491	23,727	39,218	11,619	7,991	19,610	79,579.44
South Dakota.....	1,600.26	4,595	7,038	11,633	19,507	13,417	32,924	48,600.26
Tennessee.....	19,880.58	66,519	101,884	168,403	29,959	20,605	50,564	274,212.58
Utah.....	6,136.58	6,161	9,437	15,598	16,559	11,389	27,948	52,958.58
Virginia.....	57,601.19	130,527	199,920	330,447	179,898	123,726	303,624	761,065.19
Washington.....	777.39	2,214	3,392	5,606	12,465	8,573	21,038	28,599.39
West Virginia.....	25,214.78	84,203	128,969	213,172	44,255	30,438	74,693	357,845.78
Wyoming.....	-----	-----	-----	-----	-----	-----	-----	-----
Total.....	540,511.91	1,777,500	2,722,500	4,500,000	1,777,500	1,222,500	3,000,000	8,985,511.91

TABLE 19.—*Distribution among the States of the total apportionments, including the fiscal year 1929*

State	10 per cent fund	Section 8 fund	Federal forest road construction fund	Forest highway fund	Forest road development fund	Grand total
Alabama.....	\$732.44	\$15,456.04	\$1,922.31	\$24,346.00	\$44,208.00	\$86,664.79
Alaska.....	142,152.47	469,102.30	193,549.95	3,569,316.00	180,736.00	4,554,856.72
Arizona.....	532,297.06	653,759.82	501,984.55	2,154,248.00	1,049,670.00	4,891,959.43
Arkansas.....	91,763.76	174,939.40	128,773.38	261,630.00	338,747.00	995,853.54
California.....	1,211,436.18	1,468,821.13	1,206,815.23	5,244,699.00	3,081,467.00	12,213,238.54
Colorado.....	592,936.95	753,644.90	777,307.26	2,581,765.00	1,294,252.00	6,004,906.11
Florida.....	30,737.33	119,528.14	21,534.94	87,861.00	104,802.00	364,463.41
Georgia.....	8,406.86	52,216.78	134,387.16	64,128.00	118,862.00	378,000.80
Idaho.....	782,431.70	1,196,206.13	1,867,402.82	3,927,232.00	4,805,310.00	12,078,582.63
Illinois.....				1,165.00	396.00	1,561.00
Kansas.....	1,867.27					1,867.27
Kentucky.....	722.72				86.00	808.72
Maine.....	2,203.09	32.41	3,738.77	9,867.00	19,485.00	35,326.27
Maryland.....	70.05					70.05
Michigan.....	2,016.58	7.00	3,000.00	17,876.00	55,787.00	78,686.58
Minnesota.....	31,512.62	8,106.78	108,352.03	225,585.00	305,367.00	678,923.43
Montana.....	514,610.51	753,376.05	731,497.39	3,120,251.00	2,547,094.00	7,666,828.95
Nebraska.....	16,655.44	18.98		38,142.00	26,838.00	81,654.42
Nevada.....	148,127.76	194,809.92	82,265.33	744,465.00	103,078.00	1,272,746.01
New Hampshire.....	28,366.45	341.66	10,941.30	126,662.00	114,672.00	280,983.41
New Jersey.....	118.99				83.00	201.99
New Mexico.....	311,208.15	429,627.16	509,215.36	1,631,095.00	854,800.00	3,735,945.67
New York.....	4.00				20.00	24.00
North Carolina.....	28,722.23	84,801.99	176,890.28	102,524.00	224,834.00	617,772.50
North Dakota.....	45.75	7.00				52.75
Oklahoma.....	8,515.55	65.49	2,775.17	18,368.00	22,297.00	52,021.21
Oregon.....	803,288.55	1,428,939.01	1,077,552.29	4,428,993.00	3,564,858.00	11,303,630.85
Pennsylvania.....	1,466.94	24.04	21.42	22,609.00	52,441.00	76,562.40
Porto Rico.....	3.70	7.00	3,343.09	4,877.00	11,813.00	20,043.79
South Carolina.....	1,723.63	402.10	48,028.61	10,755.00	39,137.00	100,046.34
South Dakota.....	136,495.55	83,566.15	79,341.53	277,794.00	171,017.00	728,214.23
Tennessee.....	15,984.93	78,433.37	28,092.79	78,298.00	140,629.00	341,438.09
Utah.....	340,535.16	445,415.26	464,562.35	1,328,702.00	510,737.00	3,089,971.77
Virginia.....	35,122.10	58,390.16	71,902.26	111,967.00	206,965.00	484,346.52
Washington.....	480,748.75	938,696.42	712,201.40	2,539,798.00	2,554,629.00	7,226,073.57
West Virginia.....	4,104.46	12,830.41	5,049.24	34,138.00	101,441.00	157,563.11
Wyoming.....	350,002.93	471,257.31	547,551.79	1,710,844.00	853,422.00	3,933,078.03
Undistributed.....		102,169.69				102,169.69
Total.....	6,657,138.61	10,000,000.00	9,000,000.00	34,500,000.00	23,500,000.00	83,657,138.61

TABLE 20.—*Condition of forest road funds on June 30, 1928*

Fund	Appropriations	Expenditures	Unexpended balance
10 per cent.....	\$6,116,626.70	\$5,873,933.97	\$242,692.73
Section 8.....	10,000,000.00	9,701,042.57	298,957.43
Federal forest road construction.....	9,000,000.00	8,986,736.93	13,263.07
Forest highway.....	30,000,000.00	27,353,199.27	2,646,800.73
Forest road development.....	20,500,000.00	19,238,865.51	1,261,134.49
Total.....	75,616,626.70	71,153,778.25	4,462,848.45

MAPS AND SURVEYS

During the year the Forest Service published for its administrative use 28 maps on the scale of one-fourth inch to the mile, 18 maps on the scale of one-half inch to the mile, and 27 atlas pages on the scale of 1 inch to the mile. Two special forest maps on the scales of 1 inch and three-eighths inch to the mile, respectively, were also printed. Five presidential proclamation diagrams were issued in cooperation with the Department of State.

The photographic laboratory made practically 104,000 square feet of Van Dyke, photostat, solar bromide, and blue prints, besides preparing 6,000 lantern slides and developing over 4,000 rolls of film and making 82,000 contact prints.

One of the largest individual jobs that has ever been handled by the drafting organization was the preparation of maps to accompany the report on the Mississippi flood situation. The work consisted of assembling and presenting in map form a vast volume

of data on physical features of the Mississippi basin. Separate wall maps showed natural vegetation, forest lands, critical areas, mean annual runoff, protection under the Clarke-McNary law, and the effect of deforestation on normal stream flow. These maps were prepared for congressional hearings. Reductions for inclusion in the Forester's special report on the subject were also made.

The only topographic survey of magnitude conducted during the year covered approximately 440 square miles on the Shasta National Forest, in California. This survey was based on accurate horizontal and vertical data and fully conformed to the standards prescribed by the Federal Board of Surveys and Maps. The cost was approximately \$20 per square mile. Several considerably smaller projects involving timber, grazing, and land-exchange areas were also topographically surveyed.

The great need for better maps of the more remote areas of extreme fire hazard has necessitated during the past few years so-called "drainage surveys." These surveys are not as accurate as regular topographic surveys but differ most from them in showing the configuration of the ground by rough form lines instead of contours. The drainage and cultural features are located to a standard fairly comparable to the regular quadrangle surveys executed by the Geological Survey. The horizontal control is to the standard prescribed by the Board of Surveys and Maps and is sufficiently perpetuated by bronze tablets to permit the initiation of regular topographic surveys from the tablets at any future time. This kind of survey costs about one-third as much as a regular topographic survey and will serve all administrative purposes until the latter can be made. During the year 1,044 square miles of virgin area were mapped on a drainage basis.

Triangulation nets were extended over approximately 925 square miles of the Powell National Forest in Utah and 500 square miles of the Wyoming National Forest in Wyoming, prepara-

tory to making grazing and drainage surveys.

An aerial survey of a portion of the Nezperce National Forest in Idaho was started, but inclement weather and condemnation of the airplane used for the work shortly after it was initiated forced its abandonment. The results secured, however, gave evidence that this method of mapping forest areas has decided promise.

The Geological Survey initiated but did not complete the survey of seven quadrangles which lie wholly or partly within the national forests. Accurate topographic maps though badly needed are lacking for 54 per cent of the national forests, and the Geological Survey has been unable to make much progress in providing them.

The General Land Office completed the survey of practically 100 townships within or partly within the national forests.

RESEARCH

The itemized statement of Forest Service expenditures on page — shows a total for research of \$1,139,644.32, subclassified under the four heads of (1) silvical investigations, (2) forest-products investigations, (3) range investigations, and (4) taxation study. The expenditure figures are those of the Forest Service cost-keeping records, and consequently include some expenditures for research undertaken by local forest officers as an incident to administration. Such incidental research projects are in addition to the body of systematically planned, organized, and correlated studies which seek the basic knowledge necessary for the successful practice of forestry in the United States. The latter work is financed (1) from appropriations made specifically for the purpose and from allotments of Clarke-McNary funds for the tax study, as prescribed by that law; (2) from appropriations for the Forest Service as a whole, for such purposes as general expenses, salaries, and supplies; and (3) from contributed cooperative funds, public and private. The expenditures last year from these three sources are compared with those for the fiscal year 1927 in Table 21.

TABLE 21.—*Expenditures for systematic research, 1927 and 1928*

Fiscal year	From specific appropriations for research	From general appropriations	From cooperative funds	Total
1928.....	\$929,762.25	\$58,182.84	\$54,389.88	\$1,042,334.97
1927.....	728,109.34	175,438.25	38,026.10	941,573.69

The amounts shown as derived from general appropriations are partly incidental contributions of various kinds, which are made in fluctuating degree, but in 1927 were mainly and in 1928 to a much less extent allotments of definite sums made to the branch of

research at the beginning of the fiscal year, for salaries and expenses. Table 22 shows the funds either directly appropriated for or allotted to each class of research work in 1928 as compared with 1927 and also with 1929.

TABLE 22.—*Appropriations and allotments for research work in 1928 as compared with those in 1927 and 1929*

Class of research	Fiscal year						
	1927			1928			1929, directly appropri- ated
	Directly appropri- ated	Allotted	Total	Directly appropri- ated	Allotted	Total	
Silvical investigations.....	\$250,000.00	\$38,080.00	\$288,080.00	\$337,000.00	\$16,080.00	\$353,080.00	\$354,300.00
Forest products investiga- tions.....	403,264.00	90,420.00	493,684.00	500,000.00	3,420.00	503,420.00	505,000.00
Range investigations.....	40,320.00	9,435.00	49,755.00	44,880.00	4,875.00	49,755.00	49,755.00
Taxation study.....	35,972.24	-----	35,972.24	48,665.00	-----	48,665.00	60,000.00

It will be seen that the increases in the research subappropriations for silvical and forest-products investigations were accompanied by material reductions in the drain upon general Forest Service funds. The increases were in fact largely offset by curtailments of other appropriation items and represent in the main not expansion of the work but a more logical method of financing it. The appropriation funds assigned to forest-products research for the fiscal year 1929 exceeded those for 1927 by only \$11,316. The increase for silvical investigations was \$66,220, of which \$60,000 represents provision by Congress for establishing two new forest experiment stations.

As has already been explained, research is the oldest activity of the Forest Service. It dates from 1876, when the first appropriation for Federal work in forestry was made. It is fundamental both to public and to private forestry. The legislative authorizations of the McSweeney-McNary law have created a basis for a less piecemeal method of financing and conducting the work, and consequently for a more orderly, comprehensive, and sustained attack upon the great number of unsolved problems that now hold back the development of sound policy and practice.

FOREST EXPERIMENT STATIONS

The two new forest experiment stations carry further the plan for a series of such stations to cover the major

forest regions of the United States. One was located at Columbus, Ohio, to be conducted in cooperation with the Ohio State University and to work largely upon problems relating to farm wood-lot management in the Ohio and central Mississippi Valley region. The other, the Allegheny station, was located at Philadelphia, where it will work in cooperation with the University of Pennsylvania and whence it will serve the Middle Atlantic group of States. These stations complete the organization for systematic forest research in the East. The other eastern stations are the Northeastern, the Lake States, the Appalachian, and the Southern.

For the West there are the California and the Pacific Northwest forest experiment stations, together with two smaller ones, the Northern Rocky Mountain and the Southwestern, which are not yet fully equipped to carry on the work for their respective regions. Work for the central Rocky Mountain region, formerly centering at Colorado Springs, was practically discontinued for lack of funds.

How great the need is for vigorous attack upon the problems that research must solve in the East has already been pointed out. But western needs must not be forgotten. The problems with which the Forest Service is confronted in national-forest administration call for better basic knowledge, to make possible full use of the great public forests. And the need to aid private timber growing is likewise great. As a result primarily

of our past mistaken public-land policies an enormous volume of western virgin timber, mostly on land unsuitable for agricultural development yet better suited to growing tree crops than is most of the timberland in the national forests, is awaiting a market. The owners of this timber can not afford to pay taxes and other carrying charges on it indefinitely. Many must cut currently to meet these charges; and the resulting fundamentally unstable condition of the western lumber industry chronically depresses the general market wherever its product competes, and makes the adoption of timber growing in the East more difficult. The earliest possible substitution of permanent forest enterprises based on wise land use for timber mining of the privately-owned western virgin stands, very likely to be followed by land abandonment, is not only of regional but also of national importance.

The natural advantages of large areas of the privately owned western timberlands for permanent forest management are greater than can be found anywhere else in the United States except in portions of the South. The redwood region of California affords perhaps the best natural conditions in the entire country, but much of the Douglas fir region in western Oregon and Washington is not far behind it. Fortunately the bulk of the redwood region is already under plans that contemplate permanent production. A few Douglas fir owners are likewise beginning to apply forestry. Progress, however, throughout the West will be unnecessarily and unduly slow until research has made available a greater body of knowledge on which to base sound and profitable practices. For these reasons, because of the key character of the western situation, and because of the crying need for better knowledge as a guide to good management of the public forests, the early upbuilding of the full complement of western forest experiment stations is essential from the standpoint of national interests.

A research advisory council was organized for the California forest experiment station. Such councils are appointed by the Secretary of Agriculture, and have proved a great help not only in guiding the Forest Service attack upon regional problems but also in correlating forest research by many agencies and in developing sound general regional policies. Councils previously appointed function for the Appalachian, Lake State, Southern, North-

east, and Pacific Northwest regions. They comprise representatives of such interests as the lumber and wood-using industries, forest schools, State foresters and forestry associations, agriculture, mining, banking, public utilities, and scientific organizations. Some 15 or 20 members appointed for terms of from one to four years make up a council.

The assignment of forest entomologists and forest pathologists to forest experiment stations by the Bureau of Entomology and Plant Industry was continued, with an increase of one entomologist, assigned to the California station. During the coming year two additional pathologists will be assigned to the southern station. The forest entomologists are studying at the northeastern station the white-pine weevil and the spruce-bud worm, and at the California and Appalachian stations bark beetles; the forest pathologists, located at the Appalachian and the northeastern stations, the diseases of forest trees and the decay of slash. Forest fire weather investigations are closely tied in with similar investigations by the Weather Bureau, particularly in the Pacific coast, Northern Rocky Mountain, Lake State, and Northeastern regions. Cooperative wild-life investigations are being made by the Bureau of Biological Survey, with valuable results; and plans are under way for the assignment of forest biologists to the forest experiment stations, the first station to which a biologist will be assigned being the California station.

In carrying out their programs the forest experiment stations cooperated closely with the State foresters and other forestry organizations in every region. The State forester of California is participating in a study of erosion and stream flow, and in other investigations, and the State forester of Louisiana in a survey of southern hardwood bottom lands. In Pennsylvania, Virginia, Texas, and elsewhere the State foresters assisted in the collection of field data, and in Michigan and Wisconsin the State departments are cooperating in fire and growth studies. Many forest schools also work in close cooperation with the forest experiment stations.

To aid and supplement the investigations conducted at the forest and range experiment stations, a silvicultural section was organized at the forest products laboratory, where will be concentrated much of the research on such matters as the relation of wood

structure and wood properties to tree physiology and to growing conditions, forest-tree morphology and physiology, and the influence of light on forest growth. These subjects present many important problems in which the preliminary work on technic and equipment can best be carried on at the laboratory.

The research program comprises both general and purely regional projects. The most important examples of the former are (1) a series of studies to determine growth capacity, or in other words what wood return can be expected from a given piece of forest land anywhere, and (2) a series to determine what, broadly speaking, are the silvicultural practices necessary to keep forest lands everywhere fully productive.

Naturally, both call for regional subprojects. The growth capacity of forest land and also the silvicultural practices that will make best use of it vary with the forest region and type. Of the growth-capacity studies several are nearing completion, and yield tables are now available to timberland owners and foresters for the four southern pines, spruce in the Northeast, Douglas fir in the Pacific Northwest, western white pine in the northern Rocky Mountains, yellow poplar in the Appalachian region, and the southern white cedar of the eastern coast. With the establishment of the Central States and Allegheny stations it has become possible to devote more time to the study of the northern and interior oaks, begun on a small scale several years ago, and to expand it to the entire range of the more important eastern oaks. Because of the mixture of species in the eastern hardwood forest, and since the purpose of the study is to show the entire yield obtainable from such mixtures, it is necessary to determine the growth rate of practically all the commercial hardwood species in the East. This involves the construction of over 200 volume tables. The study when completed will be a monumental piece of work.

A number of the studies to determine the desirable silvicultural practices have likewise been completed, and publications covering five of them have been issued. They cover the California pine region, the Douglas fir region of the Pacific Northwest, the hardwood region of the Central States, the western white pine and larch-fir forests of the northern Rocky Moun-

tains, and—the most recent—the Lake States region. Other reports in this series now in various stages of preparation are for the southern pine region, the central Rocky Mountains, and the Northeast, and for western yellow pine, both north and south. Each report outlines the measures which the timberland owner should adopt to grow and protect valuable timber crops.

Examples of purely regional problems under investigation are the proper management of mixed spruce and hardwood forest in the Northeast, and of the hardwoods of the Appalachian region, which supplies much of our hardwood lumber; in the Lake States, the group of problems created by the fact that there are millions of acres of unproductive or only partially productive cut-over land (a situation that is resulting in a widespread demand for information on methods of converting scrub land into productive forest), and the relation of drainage to swamp-forest growth; in the southern pine region, the development of methods of turpentine that will best fit the requirements of forest management; in the northern Rocky Mountain region, blister-rust control; in the intermountain region, the development of cutting methods to insure natural reproduction in the shortest possible time; and in California, very difficult and important problems of fire control and the relationship between cover and water supplies.

The swamp forests of northern Michigan, Wisconsin, and Minnesota occupy some 9,000,000 acres. In their present condition many of them are almost valueless for production. A typical black spruce swamp, for instance, grows only about one-tenth of a cord of wood per acre per year. Yet in northern Europe hundreds of thousands of acres of such land have been made into profitable forests. Experiments of the Lake States Forest Experiment Station begun several years ago are now showing that suitable drainage causes an immediate increase in growth. In northern Minnesota the removal of excess water has increased the diameter growth from two and one-half to three times, the height growth from two to seven times, and the volume growth from twelve to twenty-three times. The increase is considerably less in hardwood trees, such as birch and aspen, than in spruce, tamarack, and other conifers, which have more superficial root systems. Drainage also makes the top-

soil more suitable for tree-seed germination. Further study of the effect of drainage is under way.

A branch station of the Southern Forest Experiment Station is located at Starke, Fla., for the study of problems relating to naval-stores extraction. Second-growth slash and long-leaf pine stands have been worked for turpentine by different methods. Under conservative methods of chipping relatively slight injury is done the tree, and over a period of years more resin is obtained. On 1,212 trees conservatively worked the most recent results show an annual mortality from turpentinizing of only about 0.4 per cent. In a group of 600 slash pine trees worked lightly—i. e., with but one face to a tree, relatively narrow faces, and streaks of moderate and uniform depth and width—a 4-year experiment just concluded shows a loss due to the chipping of only 0.2 per cent of the trees annually as against 8 per cent, or forty times as many, in a similar adjoining group heavily worked.

For a number of years there has been under way in California a study of the effect of different cutting methods upon the rate at which natural reproduction becomes established. In connection with this study over 20,000 trees have been remeasured at five-year intervals. A recent analysis of these measurements developed a new classification of the trees in the western pine forests. It appeared that certain classes of trees, readily recognizable in the forest, are especially subject to insect attack; others are liable to windthrow or breakage, while still others make too poor growth to be worth retaining in the forest. This discovery has made it possible to select trees for cutting far more discriminatingly, and it has found general application on the national forests of the California pine region. The simplicity of the method makes the checking of marking practices on timber-sale areas easy and more systematic. Study of this method in relation to other stands bids fair to revolutionize practices in marking timber for cutting on national forests elsewhere.

Other investigations which can be only briefly touched upon include the proper management of southern California chaparral forests to prevent erosion and rapid run-off; the distance to which wind carries the seed of various conifers; the damage done by forest fires to stands of various ages; methods of thinning young

stands to increase their productivity; damage to wood lots through overgrazing; and methods of cutting in various forest types to insure rapid restocking of the forest tree species. An investigation of the fertilizing value of forest-leaf litter, just concluded by the Lake States Forest Experiment Station, showed that in white, red, and jack pine forests approximately a ton of needles per acre falls to the ground each year, the amount varying for stands of different kinds and ages from 1,847 pounds for old-growth red and white pine to 2,375 pounds for young jack pine. In addition to considerable quantities of calcium, phosphorus, and potassium the needles falling in a year on 1 acre contain an amount of nitrogen equal to that in 70 pounds of sodium nitrate fertilizer, costing commercially about \$3. A forest fire in that region usually consumes the accumulated litter of several years.

In cooperation with the State of Minnesota, the Lake States Forest Experiment Station issued a publication on the forest fires in that State following the completion of a statistical analysis of all the fires reported to the State forester for many years. The station also prepared a manual on planting practice based on extensive observations and investigations throughout the Lake States and southern Canada. This is being distributed in preliminary form pending publication. Planting and nursery research has been under way at several of the other stations, particularly at the Southern. Slash pine, now a favored species in the South because of its exceedingly rapid growth, has been found not well adapted to upland sites, since on the flat lands on which it naturally grows about 10 per cent greater survival and a 30 per cent better height growth was obtained. Root pruning long-leaf pine seedlings before they are planted apparently does not, as was formerly believed, stunt the development of these trees, but on the contrary appears to stimulate to some extent the height growth.

FOREST-PRODUCTS INVESTIGATIONS

Research at the Forest Products Laboratory seeks mainly to provide forest products of definite, unvarying quality, and to extend their supply through more scientific utilization.

Quality control is being carried back to the formation of wood in the forest. It may prove possible to grow trees for specific properties. Experiments dur-

ing the year concerned the southern pines, and density control. An experiment on the Florida National Forest now in its third year, and studies of artificial thinning elsewhere in the southern pine region, prove that density is controllable within limits. Density was chosen as the first subject of these studies because it is a fairly reliable indicator of many other wood properties, such as strength, hardness, and ease of seasoning. Apparently the size of the leafy crown of the tree determines the amount of light wood formed in the spring, while the moisture and fertility of the soil determine the amount of denser wood formed later in the year. Observations on young redwood stands in California show that the spacing of the trees produces a much greater effect on the density of the wood than does the soil composition. From the standpoint of forestry practice, better knowledge of the effect of controlled growth conditions on the structure and properties of all the important commercial species of wood is needed.

More immediate results in enabling wood to meet the need of industry for materials of known uniform properties are being sought through the development of better methods of grading and selecting lumber. The laboratory is determining the characteristic defects which occur in each of the various commercial softwoods, so that the present standard grades for softwoods may be more effectively differentiated. This study, begun last year on the southern pines, is being extended to the western softwoods at the request of the lumber industry. Study of structural columns of Douglas fir and southern yellow pine afforded new data on the relationship between defects and the strength of wood columns of various lengths, permitting the preparation of more efficient grading rules for structural posts and columns and the application of a new and more efficient formula to column design. The results of the column study and of previous work on structural timbers were embodied in the standard specification for posts and square timbers adopted last year by the American Society for Testing Materials. A similar specification had previously been adopted by the American Railway Association.

Preparatory to a further important refinement in lumber grading, that of grading lumber according to its degree of dryness, the laboratory in cooperation with the lumber manufacturers in the principal softwood regions of

the United States made extensive tests of the moisture content of all grades of softwood lumber as it is shipped. The information obtained was made the basis, by the central committee on American lumber standards, of definite seasoning grades to apply to all softwood lumber. The recommended grades were considered by the seventh general conference on lumber standards held in Washington, May 3, 1928, and final action by the trade upon them is expected in the course of the year.

Trade use of moisture grades depends largely upon the means available for measuring moisture content. The only method in common use is to oven-dry samples cut from selected boards and determine their loss in weight. This method is far too slow, cumbersome, and inconclusive to be satisfactory. The laboratory has been working on rapid methods of determining the moisture content of lumber, and during the year developed two instruments to the point of readiness for commercial trial. One is a small thermometerlike instrument which, when inserted in a hole bored in the wood, will give a reading of moisture content in a few minutes. The other is an electrical-resistance instrument which makes possible a practically instantaneous determination of moisture content. Further developments of the latter type of instrument may lead to an automatic apparatus which will test the moisture content of each board as it is being graded at the mill. The possible refinements in wood utilization through more scientific grading and selection are evident when it is realized that in any lot of lumber as now graded one board may be half as strong as another, shrink and swell twice as much, be half as resistant to decay, wear half as long, or be only half as good an insulator against heat losses.

Deficiencies in certain properties may be detrimental in one use but not in another. Hence an essential part of scientific grading is a knowledge of use requirements. Very little research has been done towards analyzing use requirements in terms of wood properties. Wood of high strength is often wastefully used where strength is of no importance; soft pieces are used where only hard pieces will withstand the wear, and so on. During the year the Forest Products Laboratory formulated plans for the investigation of certain important use requirements as funds permit, for example, the permissible range of moisture content of

wood in various house parts, the decay hazards in buildings in various regions, and the transportation hazards which shipping boxes and crates must be designed to meet. Preliminary tests of the moisture requirements in wood stock for door manufacture made available better knowledge of the moisture limits within which such troubles as opening joints, sticking doors, and lock misalignment may be avoided.

While scientific selection of wood for a given use presupposes a full knowledge of all its properties, only on the strength properties are nearly adequate data as yet in existence. They are the result of recently completed tests on 500,000 specimens of the several hundred commercial species of wood in the United States. The laboratory is now engaged in a study of the variation in strength found within each species and producing region. This will be of great aid to wood users in their choice of species and design of products. Comparable data are lacking on some 30 other properties of commercial importance.

In the field of the chemical composition of wood, the progress in the study of wood extractives, or portions soluble in water and other liquids, illustrate the practical results obtainable. The study has been hitherto principally of the extractives in redwood. They apparently have considerable effect on the strength properties of that wood, and probably account for its high decay resistance. Drying the wood decreases the solubility of the extractives—which suggests a means of avoiding the troublesome discoloration of paint coatings on redwood. A new compound, "sequoyite," has been isolated from redwood extractives, whose properties remain to be studied.

Combined chemical and microscopic studies have disclosed some interesting details in the structure of the cell wall in wood. The inner walls of the cell are made up of fibers running mostly longitudinally, but of a slight spiral arrangement. The outside layer, however, is made up of a contiguous band wound around the cell. Knowledge of this cell structure is of great value in explaining the shrinkage and strength properties of the wood. In all probability the discoveries made in the cell-structure studies will find direct application in the development of maximum strength properties in wood pulps, and in the improvement of formation and strength in the resulting commercial papers. They should also

help to explain the movement of liquids in wood, upon the rate and extent of which depend the practical operations of drying and impregnating.

Artificial treatment affords a further control of the properties of wood. The laboratory continued its experiments in treatment against decay. The work of the year related to the treating of certain refractory species for use as railroad ties, the toxicity of various preservative chemicals, notably the arsenic compounds, and the preservative treatment of building lumber with zinc chloride. Experiments with various commercial fireproofing treatments are planned.

The production of treated wood for general purposes raises new questions regarding such matters as the painting and finishing characteristics, strength, and moisture-absorptive qualities of such woods. Studies to determine the fitness for building purposes of lumber treated with zinc chloride are now in progress.

Satisfactory results in the use of wood depend not only on the wood but also on the accessory material. This is particularly true of paints. Considerable effort was given to adapting paint coatings to various woods. Development of a paint coating that will adhere to dense summerwood, especially of flat-grain boards, was sought. Its discovery, when accomplished, will greatly reduce repainting costs on house siding and trim. Another accessory material under investigation is glue. Improved practices in the gluing of various woods, developed at the laboratory, are reported in a handbook for the trade, now being published. Present research is being centered on making glues that are more durable.

Extension of the supply of forest products can be effected through the reduction of waste in manufacture, through increased yields, and through the modification of manufacturing processes to utilize new species.

Whether it pays to cut small trees, or to leave them for a subsequent cut, can be told only through systematic investigation of a whole series of problems concerning both utilization and forest management. The Forest Products Laboratory cooperated last year in a Forest Service study of such problems in connection with small mill operations in the Arkansas short-leaf pine region. Sound utilization standards are essential both for private enterprises seeking a sustained yield and for the Forest Service in its administration of the national forests in

Arkansas. Information was obtained by size classes on logging and milling costs, on the grades of lumber produced, and on the benefits of certain operating practices.

It was found that on the type of operations studied short-leaf pine trees less than 11 inches in diameter breast high do not pay their way; that fire-damaged short-leaf pine logs brought \$10.20 less per thousand feet gross scale than sound logs of the same size and position in the tree; and that careful sawing and improved operating methods produced from a given quantity of logs at least 13 per cent more lumber, worth \$2.64 more per thousand feet, than is customarily obtained. These and other results derived from the study typify the kind of information obtainable, and basic to profitable forest operations.

As a follow-up of similar logging and milling work done the previous year in the hemlock-hardwood region of the Lake States, a study was carried on to determine how utilization standards would be modified if small logs and the material in mill trimmings, edgings, and slabs were cut into dimension stock. Preliminary results indicate that much of the waste material can thus be profitably salvaged. A start was made in determining the costs of the different recognized methods of dimension stock production.

Tests to determine the suitability for boxes of certain little-used species of wood which must be logged along with more valuable woods indicated a probable use for such material in the form of low-grade thin veneer, in wire-bound boxes. The wire-bound box has generally been manufactured from clear, high-grade veneer.

A microscopic study of burned and unburned young long-leaf pine trees afforded for the first time detailed information on the injury from annual burnings prior to turpentineing. The tissues of trees which had their foliage completely scorched off in late winter, but were not killed and put out new leaves, in comparison with similar trees of uninjured foliage, showed a great depletion of reserves, retarded early growth, and an excessively reduced wood and resin tissue formation throughout the year. Their yield of naval stores was 50 per cent less than that of the uninjured trees, and in spite of the recognized hardness of the species, by the beginning of the second year of turpentineing 50 per cent of the scorched trees were either dead or no longer yielding gum.

The pulp and paper studies dealt mainly with the problem of extending the supply of raw material through increased utilization of abundant species, more complete utilization of pulpwood at the mill, and the utilization of timber wastes. The southern pines and southern and northern hardwoods were the important species studied for increased utilization. A strong white pulp has been produced semicommercially from the southern pines by means of a modified sulphate pulping method and a combined chlorine gas and hypochlorite bleaching. The indications are that such a pulp can be used successfully in the manufacture of writing, bond, and ledger papers. The next step is to duplicate commercial grades, using the laboratory equipment. Sulphate-pulping studies upon hardwoods showed that papers of catalogue and print quality can be produced, at an estimated cost comparing favorably with that in commercial practice, from furnishes of hardwood sulphite and hardwood mechanical pulps containing a small admixture of long-fibered sulphite, in place of the usual furnish made up entirely of softwood fibers. Further mill-scale trials will be arranged.

Under the semichemical mild neutral pulping process, Lake States aspen, birch, and maple can be cooked together and milled to produce remarkably strong pulps in high yields for the cheaper papers and boards. Satisfactory sulphite pulps, both bleached and unbleached, apparently suitable for use in high-grade book, bond, and writing papers, have been produced from the same species, alone and in admixture with northern conifers.

More complete pulp-wood utilization will take place if as much of the wood substance can be left in the pulp as the use requirements will permit. This has been done in the semikraft and semichemical processes and application is now being made of the same principles to the sulphite process, with the result that yields of from 65 to 80 per cent of the wood substance have been obtained as against the 40 to 50 per cent obtained by the ordinary sulphite process. This product has been substituted experimentally for standard sulphite in print and other cheap papers.

The cooperative studies of the profitable utilization for pulp of timber waste, both sawmill and manufacturing, were continued with various agencies. For example, the possibility

of producing sulphate pulp from the extracted chips which are by-products of the rosin industry in the South was investigated, and medium-grade pulps entirely suitable for use in the production of boards and the cheaper grades of wrapping papers were obtained. Rod-milling studies have been carried far enough to show that the results can be varied at will through wide ranges for particular papers from given pulps, by the design of the milling elements, and results can be produced which, so far as is known, are not capable of duplication by other means.

The results of an extensive study of air-seasoning methods in the West were brought together in report form, and are now in process of publication. With better methods losses both in quantity and quality of western softwood lumber can be reduced, the average drying time can be shortened, shipping weights can be lowered, and final moisture-content requirements can be more nearly attained. The publication discusses the results from present air-seasoning practice in the principal producing regions, and presents the general principles involved and their application to yard drying. Air-seasoning rules applicable equally to all yards can not be laid down, since the conditions vary; but certain fundamental information can be applied to work out the effect of different methods and combinations of methods upon stock depreciation, rate of drying, etc., with the prospect of worth-while financial returns through improved practice in such things as drainage in the yards, space between piles, foundations for and construction of piles, and space between boards in a course.

The results of an extensive series of sawmill studies in the "inland empire" were published as trade-journal articles, showing that closer utilization in varying degrees is entirely practicable by closer attention to mechanical factors, sawing methods, the training of workmen, and the adoption of lumber standards. Taper sawing was found to be preferable to the common practice of sawing parallel to the center line of the log. In some eight mills the best method of taper sawing showed \$11.02 higher profit per thousand feet, net log scale. Another comprehensive study showed the relation of size and defect in the important tree species of the region to the production cost and the value of the lumber. The extensive detailed tables resulting from the study offer a prac-

tical method of estimating costs and values in any specific operation.

The San Francisco Bay piling committee, made up of a group of organizations including the San Francisco office of forest products of the Forest Service and the Forest Products Laboratory of the Forest Service, published a report entitled "Marine Borers and Their Relation to Marine Construction on the Pacific Coast," embodying the results of the most intensive and comprehensive study of marine borers ever made, together with service records on some 200,000 piles in San Francisco Bay and a discussion of a large number of preservatives and processes for protecting piling.

FOREST-ECONOMICS INVESTIGATIONS

The forest-taxation inquiry field work in Minnesota and Wisconsin was practically finished and compilation of the results is well along. The Wisconsin work was largely in cooperation with the College of Agriculture of the University of Wisconsin, and the Michigan work drew heavily upon the data of the Michigan land economic survey. Plans were made and preliminary office work was begun for extending the inquiry to New England. The principal efforts of the current year, however, will be concentrated upon the Pacific Northwest, particularly Oregon. The forest-taxation problem in that region is especially urgent. Because the forests consist so largely of mature timber the problem differs from that in any portion of the East, where tax reform has to do chiefly with young, growing forests. Adjustment of taxation in the Northwest may be an important factor in prolonging our supply of large timber.

Two progress reports making available some of the results of the inquiry were issued. A digest of the various State forest tax laws, primarily for the use of the staff of the inquiry, and abstracts of these laws and a preliminary bibliography on forest taxation, intended for general use, have been prepared. Work was begun on a historical study of forest-tax legislation, and advisory assistance was given Minnesota, West Virginia, and North Carolina.

A study to ascertain under what conditions and to what extent marginal and submarginal agricultural land in southeastern West Virginia can be utilized for growing timber, and to investigate the place of forestry in the

agricultural economy of the region. was undertaken in cooperation with the Bureau of Agricultural Economics and State agencies. Endeavor was made to get at some of the underlying economic factors, such as the cost of holding land for forestry, the prospective markets for forest products, and the quantities and kinds of products that the land will yield.

Cooperation continued with the Bureau of the Census in gathering statistics on the production of lumber, lath, shingles, and other forest materials in the Western States. The reports on lumber distribution gathered in 1927 were compiled into tables showing the estimated shipments of softwoods and hardwoods from each State to every other State, and the amounts reported. This is the fifth year that the collection of such data has been made. It was found that the per capita lumber consumption in 1926 varied from 1,230 feet, board measure, in Oregon, to 100 feet in South Carolina, while the average for the United States was 300. It is proposed to expand this project in 1928, so as to show the principal sources and destinations of lumber exports. Under a proposed cooperative arrangement with the Dominion Bureau of Statistics of Canada, it will be possible to show in considerable detail the lumber distribution and consumption in all parts of North America north of the Rio Grande.

A bulletin was completed and published embodying the latest and most authoritative statistics on American forest resources, forest administration, and forest products, and was in such request that a second and third printing were necessary. The demand for reliable information on our timber supplies and requirements is becoming more and more insistent. Two popular publications outlining the situation were issued during the year, but complete information can not be given until a comprehensive forest survey of the whole country can be made, such as is contemplated by the McSweeney-McNary law.

The growing interest of private owners in forestry was evidenced by the commercial forestry conference, held under the auspices of the Chamber of Commerce of the United States at Chicago in November, 1927, and the Wisconsin commercial forestry conference, held at Milwaukee in March, 1928. Private forestry, however, to a much greater extent than public forestry, depends upon full

knowledge of the economic forces which affect the growing, harvesting, merchandising, and utilizing of timber crops. Regarding these, and the public measures that will bring about the most favorable conditions for private timber growing, there is much to learn.

RANGE INVESTIGATIONS

Approximately 70 per cent of all the feed for livestock in the 11 far Western States comes from range land, and range livestock production is one of the most important industries of these States. For stable and profitable production it is essential to know how much, during what period, and by what kind of livestock each individual range can be grazed without loss of carrying capacity.

Forest Service range research now largely centers at an experiment station in the mountains of central Utah and at two range reserves on the semi-desert low ranges of the Southwest. In the late nineties, the high mountain watersheds of Utah, according to stockmen, were practically dust beds. Not only were they failing to furnish a satisfactory feed supply for the livestock, but the soil was washing away and disastrous floods were doing damage to the valley farm and urban properties. Fifteen years of study have shown that on these ranges a satisfactory and valuable forage crop can be reestablished, which will also reduce the floods and erosion and afford better water flows.

During the first 10 years the improvement was slower than during the last 5, after improved soil conditions and an increased stand of grasses had been brought about. The greatest increase took place where the grasses had not been completely killed out. On the better soil areas, with a few grass plants still left under the protection of brush, only 2½ acres is now required to support a cow a month, as against 10 acres or more in 1912. This improvement has been accomplished largely by adjusting the degree and time of grazing to the requirements of the more valuable forage plants.

The studies have shown that total protection from grazing does not maintain, as might be assumed, the most satisfactory stand of vegetation over a period of years. Totally protected vegetation becomes dense in good years but may be materially thinned in a dry year. Grazing tends to keep the clumps of grasses smaller, and

when drouth comes the vegetation appears to be better able to withstand the deficiency of soil moisture.

Where the valuable plants have been practically eliminated their reestablishment is apt to be very slow. Artificial reseeding with cultivated forage plants has shown that Kentucky bluegrass, common or smooth brome, timothy, and sweet clover have considerable promise. The results of the studies in this field were summarized last year for publication.

Among the native species, violet wheat grass and mountain brome are giving notable results. The forage value of experimental areas has been increased from six to ten times by seeding these plants. Stockmen on the Manti National Forest, on which the Great Basin Experiment Station is located, have become so impressed with the results that practically all the livestock owners and herders are cooperating to revegetate depleted areas. They collect seed of the valuable forage plants in connection with their regular work—some only in small amounts, now and then; but others have stripped ripened seed from the more valuable plants by the sackful and scattered it on depleted areas. With from 150 to 200 men collecting and planting seed each year, marked progress is being made in revegetating such areas, at a practically negligible cost.

Intensive studies are badly needed on the intermediate and lower elevations of the intermountain region. The spring range situation at the lower elevations is especially critical. Although in early spring practically no forage grown the year before remains to be eaten, livestock are placed on the range before the plants have produced new feed. This both delays the development of the forage and lessens the quantity produced. The lack is reflected in decreased livestock production. Insufficient nourishment of ewes during lambing results in the death of thousands of lambs annually and the stunting of many more. Cattle ordinarily come out of the winter in poor condition, and when turned loose on spring range bearing little feed, and that very watery, not only do they fail to make gains, but many die of starvation.

About 150,000,000 acres of western range suitable for spring grazing is in poor condition. Because of this there is an urgent demand for too early use of at least 25,000,000 acres of national-forest ranges on which productivity is already low in consequence of prema-

ture grazing. The problem calls for intensive study throughout the West, but the need is particularly urgent on the low ranges of the intermountain region. The winter range problem is likewise becoming more and more critical in this region. The better forage plants have largely been destroyed, and many ewes die yearly of malnutrition or from eating poisonous plants because of an inadequate food supply. A much better understanding of the form of management most desirable for all types of range and a sound basis for correlating their use is essential.

Among the current investigative projects continued during the year at the Great Basin Experiment Station were studies of natural revegetation, periods of plant growth and use, plant vigor, cell sap, spring-fall range management (in cooperation with the Bureau of Animal Industry), and the correlation of the principal climatic factors with plant development.

In the Southwest 13 years of study has now been given by the Forest Service to management of the semidesert cattle ranges, which are used yearlong. The Jornada Range Reserve is in southern New Mexico. It was fenced in 1912, under the direction of the Bureau of Plant Industry. At that time it was typical open public domain range. Since fencing it has been conservatively grazed. By 1916 on the part reserved for fall, winter, and spring use the density of valuable grasses was four times that found on the adjoining open range. The region is subject, however, to severe periodic droughts. One was experienced from the summer of 1916 to the winter of 1918-19, and another from the summer of 1921 to the winter of 1925-26. By 1924 the valuable forage plants on the reserve had decreased to slightly less than one-third the maximum density attained during the period, and on the open range to 6.75 per cent of the maximum.

In 1925 most of the cattle were removed from the main portion of the reserve for that year. In 1927, following two good years of growth, the reserve range was almost back to its maximum; but the open range, although practically ungrazed in those two years, had failed to recover noticeably and was occupied mainly by worthless, poisonous, or low-value vegetation. Even under drought conditions, except during the year of disuse the reserve has afforded satisfactory cattle production. The average calf crop for the 9-year period 1915-

1924, which included seven years of drought, was 65 per cent, and the average loss was only 1.8 per cent, a net production of 63 animals for each 100 cows grazed. On the adjoining public-domain range the average calf crop was 50 per cent and the loss about 10 per cent, or a net production of 40 head per 100 cows. Thus the reserve produced 57½ per cent more calves per 100 cows than did the open range. And the reserve cattle sold for from \$2 to \$12 more per head than the outside cattle of the same age and class.

On the Santa Rita Range Reserve, in southern Arizona, the experiments have shown that it ordinarily requires from three to five years of careful grazing, or total protection from grazing, to restore a moderately depleted grama range, and considerably longer if the grama and other valuable grasses have been killed out. The experiments also indicate that a semi-desert grama range can be maintained in as good condition with proper grazing as with total protection, if not better. The essential matter is a plan of management which allows the forage plants to make satisfactory growth during about six weeks of the summer rainy period, when nearly all the year's supply of feed is produced.

It is also essential to stock the range on a basis which will allow the breeding herd to be maintained in a dry year. By utilizing approximately 80 per cent of the forage in the average year and by providing reserve pastures for the critical spring period the breeding herd has been maintained throughout the 13-year period. The range is now in excellent condition.

On the open range the number of cattle varied greatly during the period, but the average was much lower than that for an equal area of the reserve. Yet the open range is now badly depleted, and the valuable grasses start growth about three weeks later, both in the spring and summer, than on the conservatively grazed range. The average annual calf crop from 1916 to 1925 on the reserve was 73 per cent and the loss less than 4 per cent, and the cost of the average yearling on the basis of 1925 values was \$17 a head. In representative outside open-range outfits the calf crop averaged only 53 per cent, the loss averaged 10 per cent, and on the basis of 1925 values the average cost of yearlings was \$22 a head. The fat yearlings from the reserve sold for \$4 more a head and netted as of 1925, when prices were

generally unsatisfactory, 7.4 per cent on an investment of \$85 per cow, compared to a loss of 5.8 per cent on an investment of \$55 per cow on the open range.

Similar intensive studies are badly needed on the mountain ranges within the national forests of the Southwest. Drought and overstocking of these higher-elevation ranges have resulted in depletion of forage plants, injury to timber production and to watershed-protection values, and uncertain profits to the livestock business.

During the year intensive studies of the grazing and timber-production problem were undertaken on one sheep and one cattle range within the yellow-pine timber type on the Coconino National Forest, in cooperation with stockmen. Additional ranges and a number of pastures will be studied to determine the amount and character of injury to yellow-pine reproduction from varying intensities and periods of grazing use over a term of years.

The great loss which the West is suffering from soil erosion on western grazing lands was presented in part 2 of Circular 33 of the Department of Agriculture, *Soil Erosion a National Menace*, published during the year. Damage from floods, reduction in the capacity of irrigation and other reservoirs, and reduction in the productivity of range lands constitute a single problem. Of outstanding importance for correcting the situation are the reestablishing of the vegetative cover on the ranges, regulated grazing on the unreserved public lands, protection of the vegetative cover against fire, and erosion control by artificial means. Corrective action must be taken soon if far greater damage and increasing difficulty of control are to be obviated.

During the year effort was made to present the results of experiments to those who would have greatest use for them, through articles published in the livestock journals and the daily press, and directly to the stockmen at the Great Basin Experiment Station field day in the fall of 1927, where approximately 200 stockmen showed great interest in the results so far obtained. Interest in increasing the productivity of range lands and in assuring an adequate supply of feed for profitable livestock production was particularly keen. The stockmen in attendance urged an extension of the investigations to other parts of the intermountain region, and especially to the spring, fall, and winter ranges.

EXPENDITURES AND RECEIPTS

The expenditures for all purposes during the fiscal year were as follows:

General administration-----	\$373,132.28
Protection of the national forests:	
Fire protection and detection-----	1,872,810.21
Fire suppression-----	962,947.47
Protection against insects and tree diseases-----	159,763.72
Total-----	2,995,521.40

Administration of current business on the national forests:	
Administration of timber use-----	1,124,336.98
Administration of grazing use-----	972,574.30
Fish and game protection-----	119,420.06
Administration of recreation and land use-----	215,183.52
Examination and administration of power sites for Federal Power Commission and support of its personnel-----	36,824.62
Total-----	2,468,339.48

Surveys of lands and resources:	
General surveys and maps-----	161,760.94
Grazing reconnaissance-----	119,512.28
Timber surveys-----	280,391.91
Total-----	561,665.13

Land adjustment and extensions:	
Classification, settlement, and claims-----	81,838.15
Land exchanges-----	131,630.51
Acquisition under act of March 1, 1911, as amended-----	1,999,842.78
Total-----	2,213,311.44

Nurseries and tree planting-----	192,907.45
Tree planting in cooperation with States under act of June 7, 1924-----	74,976.98

Construction and maintenance of improvements:	
Construction of improvements other than roads, trails, and camp-ground improvements-----	822,650.67
Maintenance of improvements other than roads, trails, and camp-ground improvements-----	690,575.23
Camp-ground improvements-----	42,517.00
Total-----	1,555,742.90

Research:	
Silvical investigations-----	433,974.93
Forest-products investigations-----	573,702.24

Research—Continued.	
Range investigations-----	\$83,302.15
Taxation study-----	48,665.00
Total-----	1,139,644.32
Fire protection in cooperation with States under act of June 7, 1924-----	942,448.77
Protection of Oregon and California grant lands-----	60,041.56
Forestry extension-----	39,570.89
Road and trail construction and maintenance:	
10 per cent fund under act of Mar. 4, 1913-----	666,704.79
Cooperative construction of roads and trails under act of July 11, 1916-----	339,531.31
Federal forest-road construction under act of February 28, 1919-----	31,125.36
Forest development roads and trails under act of Nov. 9, 1921-----	3,028,179.03
Forest highways under act of Nov. 9, 1921-----	4,504,864.96
Road and trail construction from moneys contributed by cooperating agencies under act of June 30, 1914-----	979,710.79
Contributed from other appropriations-----	490,035.99
Total-----	10,040,152.23
Grand total-----	22,657,454.83

In addition to the expenditure for land extension itemized above in the entries "land exchanges" and "acquisition under act of March 1, 1911," national forest timber having an estimated value of \$267,036 was cut under agreements involving the acquisition of land and timber through exchange. The cash disbursements recorded under "land exchanges" cover merely the outlay incidental to examining lands offered for exchange and appraising the values involved.

The cash receipts from the national forests were as follows:

From the use of timber-----	\$3,325,079.24
From the use of forage-----	1,713,730.15
From miscellaneous uses, including the use of land, water-power sites, etc-----	402,625.41
Total-----	5,441,434.80

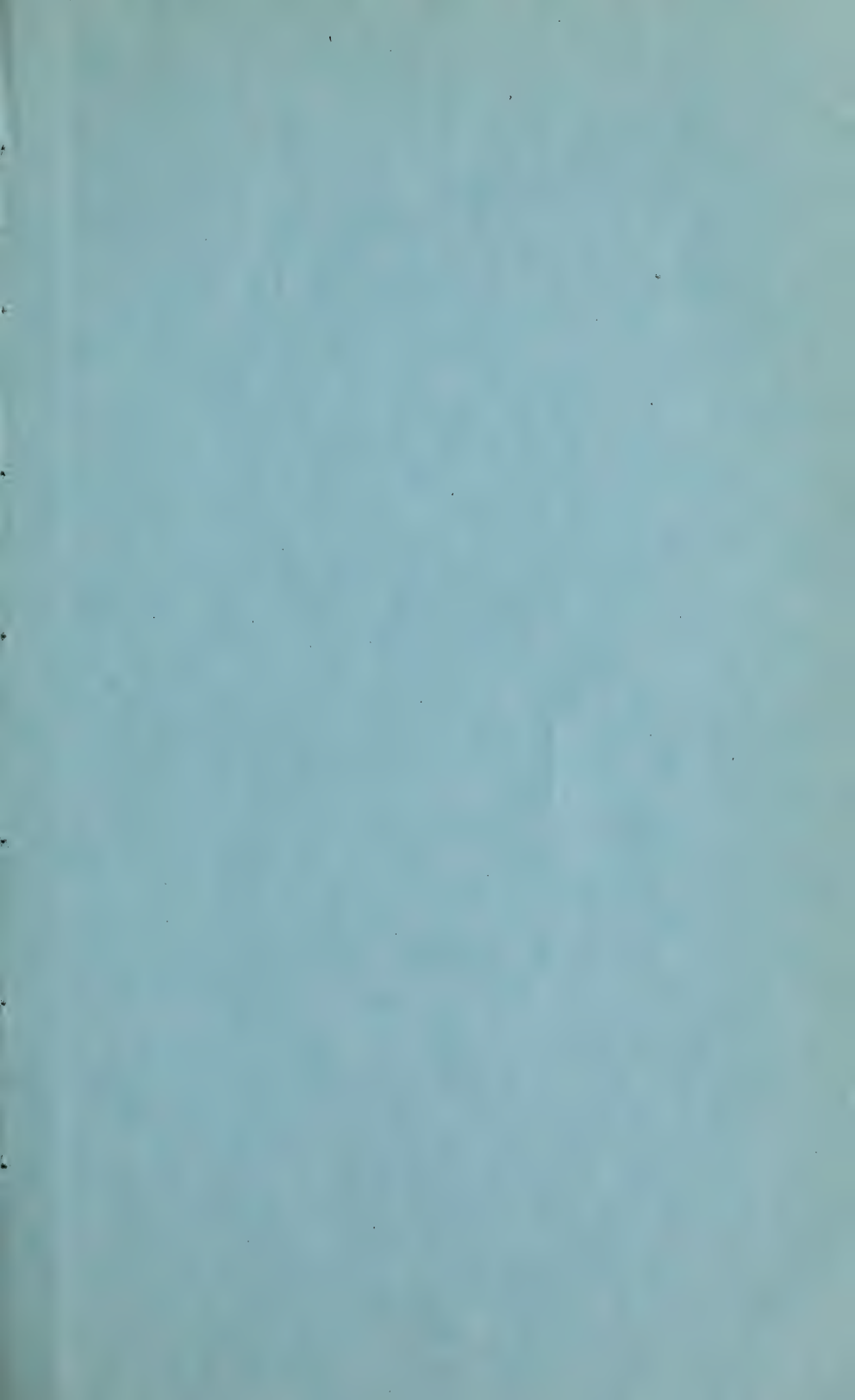
The total is greater by \$274,829.06 than that for the previous year. Receipts from timber increased \$71,836.74. Grazing receipts were greater by \$182,777.69 and miscellaneous use receipts by \$20,214.63.

In addition to the cash receipts from timber there should be credited the value of the timber cut under specific agreements for effecting land exchanges, estimated at \$267,036.

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GRAIN FUTURES ADMINISTRATION

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EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF HOME ECONOMICS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF HOME ECONOMICS,
Washington, D. C., September 7, 1928.

SIR: I have the honor to present herewith the report of the Bureau of Home Economics for the fiscal year ended June 30, 1928.

LOUISE STANLEY, *Chief.*

Hon. W. M. JARDINE,
Secretary of Agriculture.

The fifth year of the Bureau of Home Economics was completed June 30, 1928. In submitting the report for the past year it seems wise, in showing the progress of our major activities, to point out their contribution to a national program for better living and to trace briefly their relation to other lines of national development. The United States leads all other nations in its opportunity to develop such a program and in its effort to make possible satisfying living conditions for all. Our national resources and our agricultural, industrial, and commercial development all contribute to this end; but if they are to function to the greatest possible extent there must be a more definite understanding of what is a satisfactory standard of living.

Fundamentally sound standards must be developed which provide optimum conditions for family and individual development. Such standards will never be static but must always embody the results of the latest scientific research as they can be applied in bettering conditions of living in the home. As these standards are worked out there must be social and economic adjustments between the goods produced, the services available, and those which are needed in the home. Further standards are essential for the education of the consumer in the wise use of the goods produced in such abundance. Not only will such an educational program of consumption add to the physical well-being and mental satisfaction of

the individual, but also, through the better adjusted production and distribution, which it would make possible, will contribute to the social and economic stability of the country as a whole.

Food is one of the prime considerations in any standard of living. The economic value of the agencies concerned in food production, manufacture, and distribution, as well as the close relation of food to health and physical well-being, emphasizes the importance of a more stable food production and distribution program based on nutritional requirements. Production and distribution programs for food, especially perishables, must be considered in terms of dietary needs. Producers have been slow to see this. There have been no definite food-production programs. Fluctuating market demands have tended to create surpluses, alternating with periods of low production. These have been variously explained, but this much is clear: Lack of cooperation of producing groups and lack of knowledge of what markets can absorb satisfactorily have contributed to the problem. In years of surplus the consumer has been urged to use more of certain foodstuffs than was humanly possible.

It is much more difficult to establish standards for clothing than for food. Clothing is not so directly related to health, but often indicates social and economic status. Furthermore, the importance of cotton and wool production to agriculture in this

country emphasizes the need of a more intelligent utilization of textiles.

With these broad considerations in mind, specific projects have been organized in foods and nutrition, textiles and clothing, and economic problems which will assist in solving some of these consumption questions.

FOODS AND NUTRITION

FOOD COMPOSITION

If the value of food products is to be measured in terms of dietary needs it must be on a basis of composition. The need for this was early recognized by W. O. Atwater, of the Department of Agriculture. He collected and assembled the available data on food composition which have been the basis for much of the nutrition work in this country. One of the major activities of this bureau, since its establishment in 1923, has been the summarizing of all material available on food composition in order to bring Doctor Atwater's compilation up to date. The last revision of his figures was published in 1906. Since that time new foods have appeared and new analyses of staple foods have been made. In collecting the new figures on food composition these changes are being considered, and the data are being studied in detail by specialists in food production from other bureaus in order that the final averages may be representative of the foods now on the market.

Following this method, figures on wholesale cuts of beef have been published, and data on the composition of fresh fruits and fruit juices are in press.

DIETARIES

The fundamental basis of any plan for food distribution, as well as any educational program of nutrition, is knowledge of present food habits. Dietary studies made by the Department of Agriculture under Doctor Atwater's direction from 1890 to 1905 are still outstanding in this field. The bureau has, since its establishment, studied the food consumption of farm families, using data obtained in farm standard-of-living studies in cooperation with the Bureau of Agricultural Economics.

The average quantity and money value of the foodstuffs consumed by these families have been determined, and the nutritive value of these average diets has been calculated in terms of calories, protein, calcium, phosphorus, and iron, and checked against

nutritional standards. The distribution of the calories and the other factors among the various food groups has been shown. The analysis of such data from 2,500 families in nine States is now completed and is being prepared for publication. For half of these families the individual dietaries also have been analyzed to determine nutritive value and money value and the relation of these to the amount of food furnished by the farm. Food-consumption figures available from other sources are being compiled for comparison with these figures and will be included in the published results.

The records for these studies have been collected by the so-called survey method, in which the housewife estimates the amount of food used by her family during the preceding year. At the dietary conference called by the bureau in 1926 to discuss the form which future dietary studies should take, question was raised as to the reliability of the figures collected by the survey method as compared with actual food accounts kept from day to day. Since that time the studies of this bureau have been directed toward answering this question.

Data on the food consumption of individual families have been collected by both the account and the survey method. A comparison of the results obtained by the two methods has been based on over 150 family account books that have been kept during the past year and on twice that many survey schedules from the same or comparable families.

In connection with this study of method, figures on food consumption have at the same time been obtained from families consuming a minimum of food and from families of professional and business men. The food consumption of various institutional groups also has been determined. In cooperation with the home economics departments of State colleges, figures have been collected from 58 college residence halls. Food records have also been obtained from 14 correctional and charitable institutions for children, supplemented in the case of 4 institutions by detailed individual dietary studies for 80 children, covering three days each.

In the individual dietary study, which was made in cooperation with the United States Public Health Service, each child was given a physical examination. Studies of this kind open up many questions as to criteria for evaluating the diet and for ascertaining the nutritive condition of the

individual. These data are now being examined to see what correlation can be found to exist between diet and health.

As the result of a cooperative arrangement with the Merrill-Palmer School of Detroit, the bureau has had an opportunity to use similar data collected in extended studies of the food habits of about 350 children living on an island near Detroit, Mich. These records in most cases cover three years and include qualitative information on the diet of each child as well as the results of a careful physical examination. Such work, it is believed, is a long step forward in methods of analysis of data of this type.

In order to help standardize the methods used in dietary studies, the bureau published last year a bulletin setting up nutritive standards and methods of applying them to family and institutional groups. A short-cut method of calculating the nutritive value of the diet is now ready for publication. This method has been tested by the bureau and by the States through the cooperation of their resident home-economics divisions. It makes possible a very marked reduction in the time required for such calculations, and will result in a decided saving of cost and time required in making food studies.

As the result of the need shown by the dietary studies made in the children's institutions, additional work is being done in one of these institutions on menus and recipes suitable for such use.

The bureau has been fortunate in having the opportunity of cooperating with five other governmental and national agencies in the work of the Washington Child Research Center. The direction of the noonday lunch at this center has furnished a practical laboratory for the nutritionists on the staff which has been especially valuable since all problems have been studied in cooperation with the parents, a pediatrician, and a practical psychologist. Additional cooperative studies are contemplated for the coming year.

VITAMINS

In no one line of nutrition work has there been more rapid advance during the past few years than in our knowledge of vitamins and their relation to the promotion of health and prevention of diseases. Knowledge of the occurrence of these vitamins in foods is

important. It is also desirable that we know the foodstuff in which they are present, especially in the case of products prepared from natural foods by selection and processing.

The bureau has maintained for the past three years a nutrition laboratory for studying the vitamin content of foods. During the past year the study of the vitamin A, B, C, and D content of three samples of honey and one sample of honeycomb has been completed. The results of this study indicate that no appreciable amount of any of these four vitamins is present.

The recommendation of pediatricians for the routine feeding of codliver oil to children has brought on the market a number of cod-liver oil concentrates of varying value. In one of these studied in our laboratory during the past year, at the request of the Bureau of Chemistry and Soils, the amount of vitamin A was found to be much less than that claimed by the manufacturers.

In connection with the horticultural department of the University of Maryland, a study of the vitamin content of several varieties of spinach has been made. All samples were grown on the same plot of soil so as to rule out the factors entering into growth. A sample of each variety has been canned so that a comparison can be made of the vitamin content of the canned product after a period of storage. The varieties selected for study were those which bring out the color differences preferred by commercial canners. Preliminary results indicated that there was little if any difference in the vitamin content of the varieties.

In connection with some work done with a cooperative rice producers' organization, studies have been made of the practical use of rice polishings in the diet. Analyses made by the Bureau of Chemistry and Soils show this product to be very high in mineral content, especially in iron. Rice polishings have long been known to be a valuable source of the antineuritic factor of vitamin B. Work during the past two years has attached considerable importance to the foods that are a good source of this vitamin. It has formerly been considered one substance, but is evidently a complex of several different factors. Yeast is one of its most valuable sources, and rice polishings are now being studied as a possible substitute for yeast as a source of certain of the vitamin B factors. It is particularly significant at the present time owing to the possi-

bility that it may contain at least in small amount some of the vitamin that has been shown to prevent pellagra, which is still prevalent in portions of the South. Our initial studies show this to be a good source of at least one factor of vitamin B.

During the past two years it has been customary for teachers and nutrition workers to look to this laboratory for young rats to be used in demonstrating feeding experiments. Some 250 rats, 4 weeks of age, have been shipped for this purpose. Reports from those using this type of demonstration material are very enthusiastic. An undernourished animal as the result of an inadequate diet is much more convincing than any amount of abstract discussion of the subject.

PALATABILITY OF MEAT

The final test of the use of any food is palatability. Most of the studies on food production have been economic in nature and have checked the results only in terms of quality and volume. It has been difficult to obtain objective tests for palatability, and few definite studies of this kind have been made. In connection with a study on meat production in which 20 States are cooperating with the department, the bureau has aided in inaugurating and working out an objective palatability test. This is making possible the assignment of a definite palatability score for every sample of meat tested. The scores in turn can be correlated with the known factors of production and breeds. The data on tenderness, which is one of the important factors in producing beef, are being checked by comparative studies in which a mechanical test for tenderness is used.

Along with these studies, in cooperation with the Bureau of Animal Industry, methods for preparing various cuts of beef and lamb have been developed and published in leaflets. These are planned to help the housewife in wise choice and suitable preparation of the many cuts of meat at her disposal.

EXPERIMENTAL COOKERY

Various other foods have been referred to the experimental kitchen for study from time to time. Special mention should be made of the following:

In connection with the work on rice polishings referred to above, studies were made of the ways in which it might be introduced into the diet. It

was found that it can be incorporated into all quick breads up to one-third of the total quantity of flour. Satisfactory light rolls can also be made with it, and the baking laboratory of another bureau prepared bread by their formulas in which rice polishings were substituted for one-fourth of the flour. Cookies were prepared in which it could be used up to one-half of the flour. It is believed that this by-product of milled rice can be used to special advantage in institutions where children are being fed. Our studies have shown that their diets are uniformly low in vitamin B and in minerals. Rice polishings provide in cheap form valuable sources of both of these food constituents.

A study has been started of some of the most important varieties of rice raised in this country in order to discover whether or not the differences attributed to variety are fundamental or are the result of methods of cooking.

Native-grown lentils have been referred to this laboratory for special study. These were tested against the imported samples found on the market. The results showed that of the samples studied, the native-grown lentils cooked more quickly and had a less strong flavor than the imported lentils. Since lentils can be grown in abundance in certain sections of the country, and since they cook so much more quickly than the other dry legumes, it would seem that their production might be encouraged.

TEXTILES AND CLOTHING

CHILDREN'S CLOTHING

The best basis for the establishment of any standard of adequacy in clothing is its relation to health. With this in mind, a number of projects have been started in the Division of Textiles and Clothing which deal with the hygienic aspects of clothing. A study of the weight and character of infants' garments worn in different sections of this country and at different seasons is being made with the assistance of various State colleges, in order to determine recent tendencies. Skin temperatures under different types of fabrics are being measured in an effort to find which fibers and fabrics are more effective in preserving a uniform temperature of the skin.

Projects are also under way on the designing of children's clothing that will be hygienic, comfortable, and easy to launder. In order to be in accord with modern thought on child train-

ing, the garments are being studied in actual use at the Washington Child Research Center and other institutions in Washington. As a result of the investigations completed to date, leaflets on rompers and little girls' dresses have been published. Studies of outdoor garments to be used at nursery schools, of boys' suits, and of suitable designs and materials for children's underwear are still in progress. Increased knowledge concerning the relation of light to calcium utilization by the body has led to the designing of garments for small children which make it possible for them to get a maximum amount of sunlight and yet be clothed modestly. Material on this subject has been published in a leaflet on sun suits. As a by-product of all of these problems, a bibliography of approximately a thousand references on the effect of clothing on health is being prepared.

COTTON FABRICS

Projects dealing specifically with the utilization of cotton in clothing and household textiles have been continued and developed as much as possible. A study of the influence of dress styles and patterns on the cotton yardage used in individual dresses during the past 10 years was published early in the year. The results show that there was no change in general style or silhouette during that period commensurate with the fluctuating demand for yardage. The length of the skirt and of the sleeves were the only style changes which may have been of influence.

The survey of the amount and type of home sewing being done was completed and published. This showed very conclusively that more cotton dresses were being made at home than any other type of garment. The work started on the development of designs of women's dresses appropriate for the use of American-made cotton fabrics was therefore continued. Photographs of these were made available to home makers through the press and rural magazines.

Attention was also given to the possibility of more extensive use of osnaburg for household articles. This is an inexpensive fabric made of short-staple and waste cotton. It is primarily intended for industrial purposes but is an economical and artistic material for home furnishings. Household articles were constructed of this fabric, and publicity was given, by means of

special articles and photographs, to its appropriateness for these purposes. Farmers' Bulletin 1516, Principles of Window Curtaining, which was issued in 1927 to show inexpensive methods of curtaining windows and especially the use of cotton material for this purpose, is being revised.

The effect of construction of fabric and grade and character of cotton on wearing quality is being questioned at the present time in connection with the purchasing of textiles for institutions as well as for home use. This has a direct bearing on the investigations of the Department of Agriculture on the growing of cotton, and it is hoped that a number of studies can be made this coming year in this bureau which will carry the work on raw cotton through the finished fabric. Projects have been outlined in which the wearing qualities of sheets woven of known character and grade of cotton will be studied. As a preliminary step, 500 sheets of known source and history, discarded by one of the Washington hotels, are being studied in an effort to determine the type and kind of wear.

LAUNDERING AND SIZING OF FABRICS

The studies on laundering and sizing of cotton fabrics have been continued. The portion of the work dealing with a method for measuring stiffness of sized materials and the stiffness produced in fabrics by different starches and starch mixtures is ready for publication. The investigations on pliability and adhesiveness of these fabrics will go forward this coming year. A method of artificially soiling materials for experimental studies and of determining the soil removed by various laundering processes has been developed and is being prepared for publication. The study of the effects of various temperatures on the efficiency of the washing process and on the fabrics laundered is still in progress.

WOOLEN FABRICS

Studies on wool are very much needed. A preliminary compilation of material for a bulletin on the selection of wool fabrics has been undertaken. On account of the urgency of other work this has been temporarily put aside, but it is hoped that it can be completed in the near future and studies undertaken on wool similar to those now in progress on cotton.

ECONOMIC STUDIES

FAMILY EXPENDITURES

The housewife has the job of adjusting the family income to meet the various needs of family living, and in the majority of homes it is not an easy matter to stretch the income to cover all these items. Many housewives are therefore recognizing the advantages of planning their expenditures in advance and are seeking assistance in drawing up their budgets. To meet these requests, a bulletin entitled "Planning and Recording Family Expenditures" and a loose-leaf household account book have been issued.

Before suggestions can be made concerning the distribution of the family income among the various items of expenditure, further information is required about the present habits of expenditure among different types of families. In obtaining such information the reliability of the survey method must be considered. Most of the studies of family expenditures up to the present time have been made by this method. It has been recognized that some error must be present in these figures, but the extent of the error and the items most affected have not been known. A study has therefore been made comparing the figures on family expenditures obtained by survey schedules and by daily household accounts. The comparative study of food-consumption figures mentioned under dietaries has been part of this larger study, which has included all items of family expenditure.

For 50 farm families in Maryland two sets of survey schedules have been obtained, covering the years 1925-26 and 1926-27. Twenty-two of these families have kept daily accounts for 1926-27. Similar data are being obtained from groups of farm families in Ohio, Illinois, and Vermont. Particular attention is being given to food, fuel, and ice furnished by the farm.

Through the Bureau of Public Welfare of the District of Columbia, division of mothers' pensions, some 90 account books have become available and are being analyzed. As the account years end, survey schedules will be obtained from these families.

During the past year 76 professional and business families from various parts of the United States have sent in detailed weekly reports of their expenditures. Survey schedules covering the same period have been obtained from 25 of these families. Through the Vassar Institute of Euthenics,

through graduate students of Columbia University, and through groups of the American Association of University Women, survey schedules have been obtained from 125 other families. Account books and survey schedules are thus available for some 200 business and professional families for comparison with the rural studies. In all of these comparisons are being made between the figures from the schedules and those from the household accounts.

In addition to throwing light on method, these data give information on the expenditure habits of these different types of families. As soon as sufficient data have been collected to furnish representative figures they will be used as a basis for suggested family budgets and for expenditure scales for individuals of different sex and age.

TIME STUDIES

Not only has the housewife a responsibility in guiding the money expended for the household, but she must also determine how her time and energy can best be spent and guide the time expenditure of other members of the family. The time spent in various housekeeping duties directly affects the money outlay for food, clothing, and other items, and is affected by the equipment that the household provides. In order to get an adequate basis for suggestions concerning time expenditure and for equipment programs, an extensive study has been undertaken of the use of time by home makers. In this, weekly time records have been collected from 1,100 home makers in 36 States. In connection with these records, information has been obtained in regard to the size and make-up of the family, the amount of other help available, and the equipment used. The editing and classifying of these records is now finished and the tabulation of results has been started. The first report, covering New York households, will soon be ready, and others will follow. These will include a special report of the equipment used by home makers and its effect on the time spent in various tasks.

An additional 1,000 time records have been obtained by cooperating State workers in Idaho, Oregon, Rhode Island, and Washington. During the past year South Dakota has also started such a study with the expectation of adding 300 more records. The blanks and directions for collecting and classifying these records have been furnished by the bureau, and in the

tabulation of results close collaboration is being maintained with the State workers. Results from all of these studies will therefore be comparable and will give a clear picture of the labor situation in the rural home. This will be used in part as a basis for equipment studies.

In order to help the housewife in the choice of tasks when such a choice presents itself, a study has been undertaken to determine the economic value of the housewife's time. The method used in placing a pecuniary value upon the home maker's services must vary according to the purpose that the evaluation is intended to serve. A report is now in preparation discussing the nature and purposes of such valuations and outlining the methods suited to these several purposes. This will be followed by reports on valuations made with three purposes in mind: (1) To provide a basis for choice of work by home makers; (2) to determine the contribution of housewives to the national income; and (3) to improve the economic status of home makers. Some of the data required for these valuations have already been obtained, and the rest will be during the coming year.

The time required for the care of small children is of foremost importance in considering the organization of the home maker's work and the management of her time. The study of time spent in care of babies has therefore been continued and extended to include children up to 3 years of age. During the coming year the results of about 100 detailed weekly records of child care will be presented and compared with figures on care of children obtained in the study of use of time by home makers.

EQUIPMENT STUDIES

There has been much discussion of late concerning labor saving in the home. For the farm housewife, at least, the need of reducing the time and energy required for her work is evident. While the same standards of efficiency that are applicable in industry can not be applied here, some gains can be made through the organization and simplification of work. The greatest promise, however, lies in the use of labor-saving equipment.

The last few years have witnessed a tremendous increase in the manufacture of household equipment. But the very number of the labor-saving devices now available indicates the experimental stage in which they are at

present. There is need for some disinterested agency, in touch with the home and with a knowledge of the scientific principles involved, to study and determine which of them are of value to the housewife under the present situation.

The need for such a study was pointed out in resolutions presented to you, Mr. Secretary, in February, 1928, by J. B. Davidson, representing a group of research workers that met in Chicago in November, 1927. They asked the department to make a study of labor in the farm home for the purpose of ascertaining the relation of mechanical household equipment to the well-being of the farm family. This we feel is being done in the time study referred to above. They also asked the department to make a survey of the amount and nature of research in the field now under way. I wish to report that we have assembled the data which we have on this and have made plans for collecting additional information. In connection with this we are hoping to get some valuable data from the survey by land-grant colleges being conducted under the auspices of the Bureau of Education of the United States Department of Interior. We were further asked to prepare a comprehensive list of suggested research projects and to formulate a coordinated and cooperative program of research in household equipment. Such a program can only be worked out through the cooperative effort of various interested groups. Steps have been taken to enlist their interest, and committees have been appointed to send in suggestions for compilation.

HOUSEHOLD REFRIGERATION

The bureau has been fortunate during the past year in obtaining assistance from the industries concerned in a study of some problems of home refrigeration. While preliminary work on this subject has been carried on in the bureau for two years, the detailed project did not get under way until after September 15. As is usual with such studies, much of the time during the first year has been expended in getting satisfactory equipment and calibrating it. The cooperating companies have supplied three electric refrigerators of the self-contained type and a number of pairs of refrigerators suitable for use with either ice or electric units. Two of the latter have been equipped with electric units.

This makes it possible to compare the two methods of refrigeration as to cost of operation, temperatures maintained, relative humidity, and keeping of food, and also to compare the results obtained when similar ice-cooled boxes are managed in different ways.

Several preliminary studies have been made, such as the comparison of the temperatures and ice consumed in ice-cooled refrigerators of different grades. This showed that as the efficiency of the box increased there was correspondingly a saving in the amount of ice required per unit of cubic space, and a lower temperature was maintained. A simple test showed that wrapping ice retards the efficiency of a refrigerator for cooling food. Preliminary experiments have been carried on in comparable electric and ice-cooled refrigerators to measure the evaporation from uncooked cuts of lamb and to study the methods of keeping lettuce and certain fruits. Careful records have been kept of ice and electric current consumption and temperatures maintained in the refrigerators and of room temperature.

In order to obtain some definite information with reference to refrigeration in a representative number of homes throughout the country, a questionnaire has been prepared and circulated. Extension agents, home economics supervisors and teachers, and home economics association members cooperated in collecting this information. The returns from 1,455 homes having some form of refrigeration are now being tabulated. Of this total 1,300 have ice-cooled, 153 electrically cooled, and 2 gas-fired refrigerators.

A study has been made of recipes for making frozen desserts in the mechanically cooled refrigerator. A popular bulletin on the management of household refrigerators is in process of preparation.

In order to determine the temperature which should be demanded in the refrigerator, bacteriological studies were started January 1, 1928. A laboratory has been equipped, and the literature in this field has been reviewed. The laboratory work to date has been devoted largely to a study of the keeping of milk in household refrigerators. Milk was chosen because it is a food in which bacteria develop rapidly and also because it lends itself to such experimental work.

Some study has been made of absorption of flavor and bacteriology of ice cubes frozen in the mechanical units. It was found that bacterial

increase during a period of 25 days was practically negligible. The condition of the cubes after storage was found to depend largely on the original condition of the water and the care of the refrigerator. Some preliminary work has been done and is to be continued in connection with the absorption of flavors and odors in ice cubes as well as the desirability of using covers on trays.

An annotated list of 113 references to books and periodical literature on household refrigeration has been prepared. The bureau is cooperating with the American engineering standards committee in formulating specifications for household refrigerators. The work is being organized by this standards committee with the expectation that it will be carried forward under the sponsorship of the Bureau of Home Economics and the American Society of Refrigerating Engineers. We feel that this type of organization which gives us contacts with the engineering and producing groups is exceedingly valuable and helpful and is pointing the way in which other types of household equipment may be studied successfully.

THE LIBRARY

The work in the library has been directed largely to making the facilities easily accessible to the bureau staff. This has been accomplished by completing the cataloguing of the 2,000 volumes which are on our shelves and by indexing current periodical material. Gradually a card catalogue is being built up of subject matter in the different fields of home economics which is not only of value to the members of the staff, but can also be used by State home economics workers.

PUBLICATIONS AND INFORMATION SERVICE

Results of this research have continued to be issued, as in previous years, in the form of bulletins, leaflets, and other department publications, in articles contributed to magazines and newspapers, and in radio releases.

The following publications have been issued in the regular series of the department or as special contributions of the bureau:

- Planning and Recording Family Expenditures. Chase G. Woodhouse. *Farmers' Bulletin* 1553.
- Record of Family Expenditures. Chase G. Woodhouse. Loose-leaf household account book, sold through the Office of the Superintendent of Documents. (Unnumbered.)

Present Trends in Home Sewing. Ruth O'Brien and Maude Campbell. Miscellaneous Publication 4.
Children's Rompers. Mary Aleen Davis. Leaflet 11.
Cooking Beef According to the Cut. Lucy M. Alexander and Fanny Walker Yeatman. Leaflet 17.
Sun Suits for Children. Ruth O'Brien. Leaflet 24.
Dresses for the Little Girl. Maude Campbell. Leaflet 26.
Lamb as You Like It. Lucy M. Alexander and Fanny Walker Yeatman. Leaflet 28.
The Convenient Kitchen. Series of 8 charts, sold through the Office of the Superintendent of Documents. (Unnumbered.)

Manuscripts for four more bulletins are in press or ready for printing.

The information service to newspapers, magazines, and trade journals

was increased to a total of 375 items prepared and distributed during the year. The Housekeepers' Chats prepared by the radio service from material furnished by this bureau were also continued in the form of five releases each week throughout the winter and early summer.

These increased publicity services have brought a larger number of inquiries to the bureau, and during the past year 10,000 letters asking specific questions on a wide range of topics have been answered as part of our information service to home makers and professional home-economics workers.

JAN 26 1929

EXPERIMENT STATION FILE

REPORT OF THE DIRECTOR OF THE OFFICE OF INFORMATION

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.,

August 25, 1928.

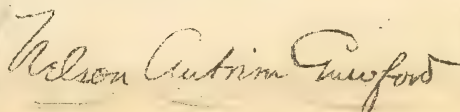
The Hon. W. M. Jardine,

Secretary of Agriculture.

Dear Mr. Secretary:

I have the honor to transmit herewith a report of the work of the Office of Information for the fiscal year ended June 30, 1928.

Respectfully submitted,



Director of Information.

The Office of Information during the fiscal year ended June 30, 1928, carried forward with increased efficiency its task of disseminating to the American people authentic information concerning agriculture and other subjects assigned to the Department of Agriculture for investigation.

Notable improvement was made both in reporting the results of basic scientific research for the use of technical workers and in popularizing scientific data. The accuracy and dignity of the Technical Bulletins and other research publications brought commendation from scientists, while the increased attractiveness, readability, and practicality of the Leaflets, the Farmers' Bulletins, and other popular publications greatly increased their usefulness. For the second time, the Yearbook

of Agriculture (1927) was prepared under the editorship of the Director of Information, and again the distinctive feature of the volume consisted in more than 300 popular articles constituting a summary of contemporary agricultural discovery. The plan of the book received wide commendation for its value to farmers.

Through the press likewise, an increased proportion of the public was reached with information. The Office of Information continued not only to supply production, marketing, and other data directly valuable to farmers, but also to present information about farming to city people, in order that they might have an intelligent appreciation of the agricultural problem.

The dissemination of information by radio yielded gratifying results. Our service was expanded and adapted to the changing conditions in the radio field. The programs met with a remarkable response from listeners, letters from whom averaged 2,500 a week during the months of most favorable receiving conditions.

Larger appropriations, especially for printing and binding, are essential if the Office of Information is to come anywhere near meeting the public demand for information. The scientific investigations carried on by the Department of Agriculture can be of no value unless funds are available for publishing the results. These investigations are made for the benefit of the people, and the people have a right to the facts that are discovered.

Specific data concerning the major divisions of the Office of Information--Publications, Press Service, Radio Service---follow:

I. PUBLICATIONS

Editorial Work

Although the number of manuscripts received during the year for publication was almost exactly the same as for the preceding year (434 as against 431), the number disapproved was twice as great (22 as compared with 11). Last year 352 manuscripts were sent to the printing office, and 68 were on hand at the end of the year, whereas this year only 303 were sent to the printing office and 109 were on hand June 30, 1928. This situation is explained by the practical exhaustion of the printing funds about the middle of April this year and the holding of edited manuscripts two and one-half months instead of only a few weeks at the close of the fiscal year as previously.

A rather critical condition in the supply of material for the Journal of Agricultural Research became apparent during the year. The Journal has for about three years been carrying in each issue practically the full number of authorized pages; namely, 100. For the past two years the number of manuscripts on hand at any one time awaiting editorial attention has been very small. On a few occasions there have been no Journal manuscripts in the files. The result has been that the Journal has been getting more and more behind its schedule, owing to the lack of sufficient material to make up the 100 pages. To meet this situation it has been decided to reduce the number of pages in each issue of the Journal until it again appears on schedule, as per date of issue carried.

Satisfactory progress was made during the year in the indexing work. In accordance with the information received from the questionnaire sent to librarians and others interested concerning various indexes of Department publications, it was decided to discontinue the 25-number indexes of Farmers'

Bulletins and Department Bulletins, and to publish only title pages and table of contents for volumes of 25 numbers. Cumulative indexes of Farmers' Bulletins 1001-1500 and of Department Bulletins are being prepared as rapidly as possible. The five-year cumulative Yearbook indexes have been discontinued. The vast work of editing and preparing material for a complete analytical index for all publications of the Department (exclusive of periodicals except the Journal of Agricultural Research and the Official Record) is going steadily forward.

In December, 1927, Miscellaneous Publication No. 9, entitled "List of Publications of the United States Department of Agriculture from January, 1901 to December, 1925, Inclusive" was published. It was prepared in the Indexing Section.

Several changes in personnel occurred during the year. Mr. B. D. Stallings, editorial assistant, and Mr. C. H. Greathouse, editor of indexes, retired after about 30 years of faithful and efficient service in the Division of Publications. The work done by Mr. Stallings was apportioned among others in the office. Miss Mabel G. Hunt succeeded to Mr. Greathouse's position as Head Indexer on November 1, 1927. Mrs. Annie Rathbun-Gravatt was appointed December 1, 1927, to continue Miss Hunt's former work, and on February 16, 1928, Miss Mary Bradley was appointed to the position left by Mrs. Gravatt, who resigned to accept a position as editor of scientific manuscripts in the Bureau of Plant Industry.

Mr. C. M. Arthur, editor of scientific publications, resigned, effective February 29, 1928, to accept a position at a much higher salary as Technical Editor at the Forest Products Laboratory at Madison, Wisconsin. Mr. T. Swann Harding of the Bureau of Dairy Industry was transferred to this office June 1, 1928, to fill the position left vacant by Mr. Arthur.

New Manuscripts (Including Revision for Publications Requiring New Titles and Numbers) for Department Publications Received July 1, 1927 - June 30, 1928.

ment Publications Received July 1, 1927 - June 30, 1928.

Total number of MSS. received	Number of MSS. disapproved	Number of MSS. sent G.P.O.	Number of MSS. on hand June 30, 1928.
Farmers' Bulletins 66	3	44	19
Department Bulletins 24	9	14	1
Department Circulars 25	--	9	16
Miscellaneous Circulars 13	6	7	--
Circulars 30	--	30	--
Technical Bulletins 116	--	86	30
Statistical Bulletins 2	--	2	--
Yearbook Separates 37	--	--	37
Soil Surveys 17	--	17	--
Service & Regulatory Announcement 53	--	53	--
Leaflets 34	1	33	--
Mis. unnumbered 7	--	7	--
Coop. Ex. Work Report 1	--	1	--
Miscellaneous, Pubs. 6	--	--	6
Reports 21	3	--	--
Total 434	22	303	109

Article for Journal of Agricultural Research

July 1, 1927 - June 30, 1928.

Number of MSS. on hand July 1, 1928	Number of MSS. received July 1 - June 30	Number of MSS. disapproved	Number of MSS. sent G.P.O.
Bureau 16	73	6	45
Station 10	52	8	39
Cooperative --	1	--	2
Total 26	126	14	86

PRINTING

For the fiscal year 1928 Congress appropriated \$738,000 for printing and binding. In spite of constant economies practiced in the ordering of printing matter, great difficulty is experienced in making the money available cover the needs of the department. The following statement shows for the various types of publications the amount spent and obligated during the fiscal year. It will be noted that there is a carry-over of \$57,596.56, to be transferred to the appropriation for 1929.

Annual reports of bureaus.....	\$9,692.14
Binding.....	18,533.06
Technical Bulletins.....	53,490.85
Circulars.....	14,398.34
Leaflets.....	4,979.22
Farmers' Bulletins.....	133,706.49
Farmers' Bulletin Lists.....	14,896.89
Field Printing.....	2,946.59
Journal of Agricultural Research Separates.....	16,213.74
Miscellaneous Publications.....	24,936.46
Soil Surveys - Field Operations.....	29,094.21
Advance Sheets.....	62,189.51
Statistical Bulletins.....	10,008.27
Yearbook (inc. part of charge for 1926 Yearbook)..	56,124.85
Yearbook Separates.....	1,944.79
Miscellaneous.....	238,363.41

Periodicals:

Clip Sheet.....	3,764.50
Crops and Markets.....	60,548.18
Exp. Station Record.....	19,196.01
<u>Journal of Agricultural Research</u> ...	5,200.78
<u>Weather Review</u>	11,392.47
<u>Agricultural Situation</u>	2,691.95
<u>Forest Worker</u>	1,283.85
Total Periodicals.....	104,077.74

\$795,596.56

PUBLICATIONS PRINTED DURING FISCAL YEAR 1928.

SERIES	NEW		REPRINTS		TOTAL	
	Titles	Copies	Titles	Copies	Titles	Copies
Farmers' Bulletins	31	1,802,253	479	9,565,706	510	11,367,959
Department Bulletins	13	156,000	41	117,700	54	273,700
Department Circulars	8	56,500	14	81,000	22	137,500
Misc. & Secretary Cirrs.	7	292,500	9	61,000	16	353,500
Technical Bulletins	75	573,155	8	37,500	83	610,655
Statistical Bulletins	5	36,500			5	36,500
Yearbooks.....	1	20,000			1	20,000
Yearbook Separates...	37	41,600	10	27,500	47	69,100
Soil Surveys.....	17	17,000			17	17,000
Service and Reg. Anns.	53	341,300	1	5,000	54	346,300
Journal of Ag. Research Reprints	139	219,585	4	2,500	143	222,485
Department Leaflets	29	698,500	6	170,000	35	868,500
Miscellaneous.....	115	2,233,820	4	10,000	119	2,233,820
Circulars.....	30	437,500	5	53,000	35	490,500
Miscellaneous Publications	21	930,650	1	2,500	22	933,150
Contents Dept. Bulletins	10	12,000			10	12,000
Periodicals:						
Journal of Ag. Research	24	48,000			24	48,000
Experiment Station Record	22	158,000			22	158,000
Public Roads.....	12	48,600			12	48,600
Crops & Markets & Index..	14	1,686,000			14	1,686,000
Official Record & Index..	52	840,200			52	840,200
Clip Sheet.....	52	365,500			52	365,500
Agricultural Situation...	12	144,000			12	144,000
Forest Worker.....	6	6,800			6	6,800
	785	11,157,763	582	10,133,406	1367	21,291,169
Farmers' Bulletin Lists			3	11,317,300	3	11,317,300
TOTAL.....	785	11,157,763	585	21,450,706	1370	32,608,469

Illustrations

The Section of Illustrations made 1,655 drawings in the drafting room, and 179,055 prints in the photographic unit. For the sale of photographic prints, bromides, lantern slides, and photostats there was received \$2,492.80. Reimbursement from the various bureaus for material used in photographic work amounted to \$9,336.22. Photographers made 332 field trips for the various bureaus of the department. Following is a tabulation showing the drafting work and photographic work done in the Illustration Section:

PHOTOGRAPHIC WORK

Photographic prints.....	109,079
Negatives.....	13,450
Negatives developed.....	1,960
Rotaprint plates.....	325
Lantern slides.....	15,978
" " bound.....	9,302
" " colored.....	1,227
Bromide enlargements.....	2,912
" " mounted.....	2,371
" " colored.....	91
Solar Bromide enlargements...	1,606
Prints dry mounted.....	4,116
Transparencies.....	67
" colored.....	51
Photostats.....	16,520

Total..... 179,055

DRAFTING WORK

Drawings.....	152
Graphs and charts.....	412
Maps.....	39
Lettering.....	364
Retouching.....	99
Layouts.....	361
Airbrush.....	45
Coverpages.....	54
Posters.....	14
Miscellaneous.....	115

Total..... 1,655

Distribution of Farmers' Bulletins and Miscellaneous Publications

Publications to the number of 33,716,481 were distributed during the year. Of this number 13,152,367 were Farmers' Bulletins and 20,564,214 were miscellaneous publications, of which 11,266,767 were Lists of Farmers' Bulletins. This large distribution was made from a stock of 44,373,435, comprising 11,732,715 publications on hand July 1, 1927 and the 32,640,720 received during the fiscal year just ended, leaving a balance on hand June 30, 1928 of 10,656,954. Compared with the distribution of the previous year there was an increase of more than 6,000,000. By far the greater part of this increase occurred in the distribution of Farmers' Bulletins and Lists of Farmers' Bulletins. The distribution of Farmers' Bulletins was greater than any year since 1923, while the distribution of Lists of Farmers' Bulletins exceeded that for the last fiscal year by 5,622,710. These lists were distributed almost entirely by Members of Congress.

The distribution by orders from Members of Congress (9,065,441 Farmers' Bulletins) was the largest since 1922, an increase of 1,214,013 over the distribution for the previous fiscal year. Undoubtedly there would have been a much larger distribution by these officials had not many of our most popular bulletins become exhausted before the end of the fiscal year.

Following is a summary of the Congressional and miscellaneous distribution of Farmers' Bulletins from July 1, 1927 to June 30, 1928:

On Hand July 1, 1927		7,861,686
Bulletins Issued		<u>11,367,959</u>
		19,229,645
Distributed by Congress	9,065,441	
Initial distribution of new bulletins	90,527	
Orders from divisions in Department	585,013	
Extension Service Orders	1,763,744	
Miscellaneous Orders	<u>1,647,542</u>	<u>13,152,267</u>
On hand June 30, 1928		6,077,378

A summary of the receiving and shipping work is given below:

SUMMARY OF WORK HANDLED BY RECEIVING CLERK FROM JULY 1, 1927 to JUNE 30, 1928.

Month	No. of Pkgs. Pubs. Received from G. P. O.	No. of Copies of Pubs. Re- ceived from G. P. O.	No. of Pkgs. Job Work Rec'd from G. P. O.	No. of Copies of Job Work Rec'd from G.P.O.	No. of Pkgs. sent from Div. of Pubs.	No. of Bgs sent from Div. of Pubs.
1927						
July	417	200,486	2,822	3,953,666	6,270	325
August	354	95,672	3,282	4,577,856	6,681	309
September	408	122,364	3,939	4,216,190	7,422	345
October	461	92,597	2,454	4,902,340	5,950	316
November	277	885,003	3,274	4,538,973	6,389	338
December	256	31,135	2,319	3,775,346	6,650	325
1928						
January	333	125,047	3,023	5,675,850	7,645	449
February	403	90,868	3,787	7,558,912	6,215	425
March	488	89,917	3,852	5,193,662	6,368	370
April	299	37,879	3,386	5,561,410	7,435	350
May	419	74,418	2,419	4,565,492	6,714	328
June	366	73,193	3,217	4,753,573	5,591	319
Totals	4,479	1,118,579	37,774	59,293,270	79,160	4,199

Addressing, Duplicating and Mailing

An increase in the amount of multigraph work necessitated the installation of an additional Monotype casting machine. This caster was purchased outright. In addition there were purchased from the Langston Monotype Machine Company two new keyboards and two Monotype casting units. These machines had been rented at an annual rental of \$3,600. Also there was purchased a new A-4 automatic addressing machine for use in this unit to replace worn-out equipment. There was placed in use a new Addressograph plate, which will replace the old plates now in existence, saving considerable in the cost of plates and in storage room.

The total number of duplicated impressions was 51,779,037. Of these 32,222,243 were on the mimeograph and 19,556,794 on the multigraph. Seventeen thousand and seventy-one dermatype stencils were cut in the Addressing, Duplicating, and Mailing Section, in addition to which many were cut in the bureaus.

Mailing Lists

The work of the Mailing Lists Section for the fiscal year 1928 was, to a large extent, an expansion of ideas formulated during the fiscal year 1927. The establishment of a list of officials to receive a notification copy of each publication improved a system which was unsatisfactory. A special envelope was prepared bearing the words "Notification Copy", printed diagonally across the left end, in outline type with red ink. Three lists were consolidated, duplications eliminated, changes made, and the names placed on stencils.

Improvements were also effected in the details of handling notification cards for new publications and in the use of franks for miscellaneous publications mailed from the Superintendent of Documents.

A new Key Index of the Mailing Lists, revised to May 15, was issued.

Much time and attention have been devoted to schemes for initial distribution of new publications in order to avoid the expense of unnecessarily or unjustifiably large editions often requested by the bureaus. This work has been handled by the Mailing Lists Section since the beginning of the calendar year 1927.

II. PRESS SERVICE

The year has shown a steady increase in demand for the information distributed by the Press Service. Requests from newspapers and syndicates for regular and special services have been on the increase and the staff has been taxed to supply material regularly for the weekly agricultural feature page of the Associated Press, for the Western Newspaper Union, and for a number of farm and home publications that have asked for special illustrated articles. The weekly Associated Press agricultural feature page is sent to approximately 1,000 member newspapers well distributed from coast to coast. From 50 to 75 per cent of the stories sent out in this sheet, including illustrations, originates in whole or in part in the Press Service. Many graphs prepared in the department have been used by the Associated Press, and we plan to prepare special ones for its use and for the use of farm papers and other publications that may want such a service.

During the year we issued for limited circulation a number of articles with photographs, and the clippings and letters from editors indicate the desirability of using this type of release more frequently. In one instance a three-part illustrated article on world wool conditions was sent to all sheep and wool publications and was used by perhaps half of them, and, in response to requests, several sets were sent to other editors later. Similarly satisfactory results were obtained from a picture feature on hay making and marketing, the text in this instance being limited to rather long legends. The use of photographs could be increased with good results.

The Foreign Language Information Service continues to provide us the best possible means of reaching the foreign-language press throughout the United States. This organization's 1927 report shows that it used 234 of our releases. One article was used by 117 of the papers taking this service.

During the year ending June 30, 1928, the Press Service issued 934 regular mimeographed releases totaling 1,480 pages, 33 special articles averaging about 3 pages each, 125 bulletin reviews, 37 statements by the Secretary, and 4 statements by the Assistant Secretary. The Western Newspaper Union received 1,152 articles, most of them selected from the mimeographed releases and the Clip Sheet, including 250 short special articles, many of them illustrated. A number of papers that have requested articles for their home departments have received an average of about ten illustrated articles each month.

Page, Line, and Paragraph, the service to country weeklies and semi-weeklies, now goes to about 3,000 editors.

We have continued sending to the agricultural college editors occasional special reports that contain material of value in the preparation of State releases or for reference. In addition they receive all mimeographed releases and the weekly Clip Sheet. The releases and clip sheets from the colleges contain a liberal sprinkling of Department material and occasional letters from the editors show that personal letters to them are effective in getting wider distribution for the results of department work.

There has been an increasing demand from Washington correspondents and press associations for commodity information such as that contained in Foreign Crops and Markets and the cable reports that come in to the Bureau of Agricultural Economics. Special lists are maintained for this service and the distribution is largely by messenger. One press association now is receiving each Saturday all information on Russian crops. An average of three special foreign crop statements in the form of carbon copies are distributed each day by messenger.

III. RADIO SERVICE

Along with other factors in the rapidly-developing radio art, the Radio Service of the United States Department of Agriculture during the fiscal year 1927-28 went through a period of rapid expansion and at the same time of stabilization.

The expansion is represented, in one phase, by the number of stations broadcasting Department of Agriculture educational program features. Exactly 149 stations transmitted one or more of the Radio Service's daily or less frequent releases during the season. By features, the broadcasting was as follows:

Five-days-a-week features--Housekeepers' Chat, 101 stations; Noon Farm Flashes, 111 stations.

Three-days-a-week feature--U. S. Radio Farm School, 73 stations.

Weekly features--Insect and Wild Animal Talks, 67 stations; Poultry Chats, 79 stations; Primer for Town Farmers, 74 stations; Young Folks' Program, 68 stations; Farm News Digest, 111 stations.

Bi-weekly feature--Chats by the Weather Man, 76 stations.

Monthly feature--Agricultural Situation Review--102 stations.

Cooperating stations were situated in 42 States and the District of Columbia. States without cooperating stations either have no radio stations, or very few, weak stations, and depend largely for broadcast reception upon stations in surrounding states.

All told, cooperating stations devoted more than 1,000 hours each month to the broadcast of farming and home making information contained in the Radio Service releases. At prevailing commercial rates, this broadcasting time would command more than \$1,000,000 for the season.

In common with other users of radio, the Department found last year that a different type of response is coming from broadcast listeners. Indeed the effect of the stabilization of radio--its acceptance as not a novelty but a part of the daily life of the listener--was more marked in response to educational programs than to any other.

The 1927 listener to the Department programs in less degree than those of other years wrote merely appreciative letters. As a rule he wrote only when he wished to submit a specific question rising from information broadcast, or to ask for a publication mentioned in the broadcast.

Nearly every return from 1927 listeners, therefore, testified that the broadcasts touched or pointed out to the listener a definite informational need. Requests for publications mentioned in the broadcasts indicated the increasing number of persons reached by this new educational agency. Aunt Sammy's Radio Recipes, a cookbook developed by the Bureau of Home Economics, and sent to broadcast listeners of the "Housekeepers' Chat" who requested it, went through four printings, and a total of 185,000 was distributed. The Farm School lessons in agricultural economics were published and 45,000 of these booklets were issued.

Among the fruits of the year's experience were a number of findings in regard to the most effective methods of presenting information by radio. It was found, for example, that the dialogue method was impracticable, even for many of the largest stations, because of their small personnel during the daylight hours which have generally been assigned to educational programs. As a consequence the monologue form, made dramatic and interesting by numerous devices, has been generally adopted for the releases scheduled for daylight broadcasts.

The most important new shift in program making arising during the year is

U.S. FARM RADIO PROGRAM REGIONS

1. CORN BELT AND CORN AND WHEAT BELT

2. WINTER WHEAT BELT

3. COTTON BELT AND SUBTROPICAL COAST

4. SPRING WHEAT, GREAT PLAINS, ROCKY MOUNTAIN, AND ARID INTER-MOUNTAIN

5. PACIFIC COAST

A hand-drawn map of the Four Corners region. The map shows the intersection of four states: New Mexico (N.M.), Colorado (COL.), Utah (UTAH), and Arizona (ARIZ.). The map is labeled with state abbreviations: N.D., S.D., N.E., MONT., WYO., COL., UTAH, and ARIZ. The text 'SPRING WHEAT, GREAT PLAINS, ROCKY MOUNTAIN' is written across the top, and 'AND ARID INTER-MOUNTAIN' is written across the bottom. A small triangle marks the intersection point of the four states.

the planning of features, especially those dealing with crops, soils, and kindred topics, on a distinctly regional basis. Throughout the 1927-28 season the programs were prepared in such manner as to indicate subject matter of regional application only. Program regions have been set up for the 1928-29 season, and the broadcasts will be prepared separately for each region, as shown on the accompanying map. Announcement of this step, just at the close of the fiscal year, has met an enthusiastic welcome from broadcasters, especially those of the South, the West, and the Pacific Coast.

How radio broadcasts tie in with other educational methods in the conduct of emergency campaigns again was shown during the past season by the use of this agency in the corn borer control campaign. A series of nine weekly broadcasts was sent to listeners by 46 cooperating stations in infested and border states. The broadcasts were prepared by the Radio Service on the basis of approved data supplied by the Editorial Office of the Extension Service.

The present trend of the radio broadcasting set-up of the nation toward organization of hook-up systems of "chains" presenting simultaneously the same programs through large numbers of stations brings to the Department new opportunities of unifying rural thought and action. One of the most striking demonstrations of what may be done along this line was arranged by the Radio Service, the Extension Service, and the National Broadcasting Company--a National Radio Night for 4-H Clubs broadcast from Washington. Twenty-three stations affiliated with the National Broadcasting Company sent this one-hour program to some 300,000 club members and leaders, beside the usual audience of broadcast listeners. The club members, meeting locally, heard the same talks and music, sang the club songs, and repeated the club pledge with the 150 state club champions in the group at Washington.

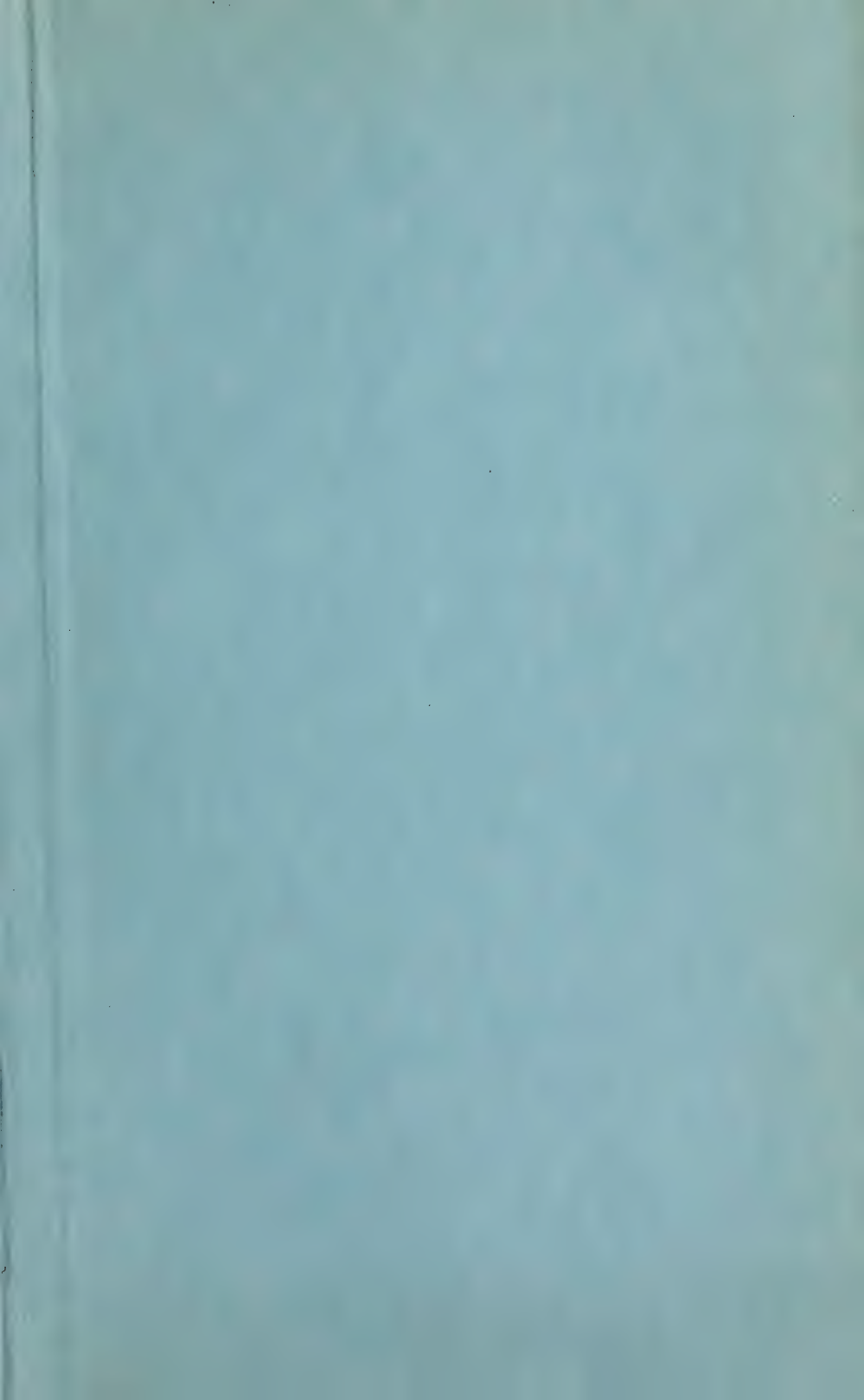
Indicated developments of the near future along this line will make it possible for the Department's workers to tell each day from Washington the agricultural "spot news" of the moment to listeners tuned in on a score or more of stations.

This new departure will reinforce, not replace, the syndicate manuscript service now offered by the Department. The Radio Service will carry on as heretofore this type of program. For 1928-29 two of the favorite daily features of the past seasons--the Housekeepers' Chat, and the Noon Farm Flashes--are scheduled, the latter on the new regional basis. A third daily service, the Farm Forum, will be inaugurated. This latter represents a reorganization and an expansion of the former Farm School, carrying a greater variety of subject matter, and developed as a regional feature.

From the Bureau of Entomology, the Bureau of Biological Survey, the Weather Bureau, and the Forest Service will come a new feature, "Outdoors with the Scientist." "The Primer for Town Farmers" and "The Agricultural Situation Review" will be continued. "Farm Science Snapshots," a weekly radio periodical will summarize the research findings of the nation's agricultural scientists, and their significant statements for busy listeners. A series of Farm Playlets, one each month, will dramatize solutions of rural social problems.

A decrease in the number of stations broadcasting the syndicate services during the coming year may be expected as a result of consolidations of stations under the enforcement of the Dill-Davis Radio Act of 1928, and the reduction of time schedules of others. Improvements in reception conditions, and better equipment of transmitting stations may be expected, however, to increase the number of listeners.

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DEC 14 1928

REPORT OF THE LIBRARIAN

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE LIBRARIAN,
Washington, D. C., August 31, 1928.

SIR: I have the honor to submit herewith the report of the library for the fiscal year ended June 30, 1928.

Respectfully,

C. R. BARNETT, *Librarian.*

Hon. W. M. JARDINE,
Secretary of Agriculture.

ACCESSIONS

The number of books, pamphlets, and maps added to the library during the year by gift, purchase, and exchange was 15,805, an increase of 1,637 over last year. This increase was in the number of items received by gift, the number of books added by purchase being less than last year owing to decreased funds for book purchases. The detailed figures follow:

	1927	1928
Purchases:		
Volumes.....	2,207	2,098
Pamphlets.....	90	158
Maps and charts.....	7	37
Serials and continuations.....	643	649
Total.....	2,947	2,942
Gifts:		
Volumes.....	1,018	1,600
Pamphlets.....	1,020	1,460
Maps.....	45	73
Serials and continuations.....	5,408	5,519
Total.....	7,491	8,652
From binding periodicals and serials.....	3,473	3,934
New current periodicals.....	257	277
Total accessions.....	14,168	15,805

The number of books received from the Library of Congress by copyright transfer was 137.

The amount of money spent for books, periodicals, serials, and maps from 1919 to 1928 is given in Table 4.

As the available funds were insufficient to meet the demands for new books during the past year, little progress was made in the acquirement of old, out-of-print books, and practically no progress was made in the completion of imperfect files of periodicals. Among the more important of the few old books which were obtained were the following:

Barth, J. M. De culice dissertatio. 1737. (The first book entirely devoted to the mosquito.)
Cluyt, D. O. Vande byen. 1648.
Estienne, Charles. De re hortensi libellus. 1542.
Gesner, Konrad. Catalogvs plantarvm latinè, graecè, germanicè et gallicè. 1542.
Glorez, Andreas. Continuation der Vollständigen hauss- und land bibliothec. 1701-02.
Linné, Carl von. Skånska resa. 1751.
Peterkin, Joshua. A treatise on planting. Ed. 2. 1790.
Spain. Ministerio de fomento. Gaceta agricola. t. 1-20. 1876-Sept. 1881.
Trattinnik, Leopold. Thesaurus botanicus. 1819.
Weston, Sir Richard. A discours of husbandrie used in Brabant and Flanders. 1650.

CATALOGUING AND CLASSIFICATION

The record of the material classified and catalogued during the year, compared with the previous year, is shown below:

	1927	1928
Volumes.....	3,225	3,698
Pamphlets.....	1,110	1,618
Maps and charts.....	52	110
Continuations and serials.....	6,051	6,168
Volumes received from bindery.....	2,252	2,267
Volumes in binders.....	1,221	1,667
New current periodicals.....	257	277
Total.....	14,168	15,805

In addition to the material which was fully catalogued, author cards only were made for 5,132 "reprints" and 294 pamphlets.

The amount of uncatalogued material on hand on July 1, 1928, was as follows: Volumes, 1,114; pamphlets, 1,545; continuations, 59.

The number of titles prepared for printing by the Library of Congress in "Agr." series and the number of titles received for 1927 and 1928 are shown below:

	Prepared		Printed	
	1927	1928	1927	1928
Accessions and recatalogued books.....	606	1,031	887	907
Department publications.....	417	388	411	429
Agricultural periodicals.....	82	94	88	94
Total.....	1,105	1,513	1,386	1,430

The number of manuscript cards waiting to be sent to the Library of Congress on July 1, 1928, was 815 as compared with 866 on July 1, 1927.

The number of cards added to the catalogue was 22,382. The cards withdrawn numbered 2,036, making a net addition of 20,346 as compared with 20,413 last year.

In addition to the catalogues maintained by the main library, which include records of all the books belonging to the department, there are a number of extensive special-subject catalogues and indexes maintained by the libraries of the various bureaus. The number of cards added during the year to these special catalogues and indexes is shown below:

Bureau	Number of cards
Agricultural Economics.....	10,428
Chemistry and Soils.....	2,272
Dairy Industry.....	5,991
Entomology.....	9,151
Office of Experiment Stations.....	4,228
Forest Service.....	8,760
Home Economics.....	5,064
Plant Industry.....	30,143
Public Roads.....	11,373
Total.....	87,410

With the growth of the collections and the expansion of the department's activities, new classes need to be added to the library classification, and old ones need to be subdivided. A few

years before the World War considerable progress was being made each year in the work of reclassification, but this work was interrupted during the war period, and only slight progress has since been made. During the past year the number for transportation was subdivided, and also the numbers on the books and catalogue cards were changed. A tentative classification was also drawn up for vegetables. This class and other classes under horticulture are urgently in need of subdivision, and it is hoped that it will be possible to complete the reclassification of the books on these subjects during the coming year.

PERIODICALS

The record of current periodicals received by purchase, gift, and exchange, compared with the record for 1927, is as follows:

	1927	1928
Number of different periodicals received by purchase.....	1,132	1,130
Number of different periodicals received by gift and exchange.....	2,316	2,553
Total number of different periodicals received.....	3,448	3,683
Number of additional copies purchased.....	235	233
Number of additional copies received by gift and exchange.....	186	204
Total number of periodicals purchased, including duplicates.....	1,367	1,363
Total number of periodicals received by gift and exchange, including duplicates.....	3,869	4,120

The dailies received by the library are not included in the figures given above. The number of different dailies received currently is 78, and extra copies of 39 are purchased.

The number of annual reports, transactions, proceedings, and other serials of infrequent issue received in the past year in addition to the current periodicals was 6,168.

A daily record of the number of current periodicals handled in the current periodical section was kept during April and May. This record, compared with a similar record for 1927, is as follows:

	Total		Daily average	
	1927	1928	1927	1928
Received by mail.....	11,562	12,158	226	238.39
Received from circulation.....	10,429	12,890	243	252.74
Special numbers charged.....	1,642	1,811	33	35.51

BINDING

The number of books and periodicals sent to the Government Printing Office for permanent binding was 2,480, a decrease of 628 as compared with 1927, owing to the decrease in funds available for binding.

In addition to the books and periodicals permanently bound, 2,757 were laced in temporary binders, and 1,167 current numbers of serials were added to files already in binders. The number of pamphlets stapled in binders was 1,150.

It was necessary to stop practically all binding in April on account of lack of funds. The supply of several sizes of binders, which are obtained from the Government Printing Office, was also exhausted, and it was impossible to get more. This decrease in binding is a serious matter as the binding of periodicals and other serials is necessary for their preservation and to make them convenient for consultation. An increase of \$20,000 for the library binding is urgently needed. This work is now paid for from the funds for the printing and binding of the department, but it has never been possible to obtain from this fund a sufficient amount for the library binding, as the total amount available for the department printing and binding has not been adequate to meet the needs for printing alone. In the past few years it has been increasingly inadequate on account of the increased cost of printing. The amount of money allotted to the library from the printing and binding fund in 1927 was \$13,173.75, in 1928 it was \$10,045.07, and for 1929 it is only \$7,500. In 1927 the number of volumes sent to the bindery was 3,108, in 1928 it was only 1,528, and in 1929 it will probably be less than 1,000. As the library receives more than 9,000 current periodicals and serials the inadequacy of the binding fund will be evident. The increase of \$20,000 is needed in part for the current binding and in part to make up the arrears of the past few years.

DUPLICATES

As in previous years the sorting and disposition of duplicates required much time. These duplicates are for the most part Government, State, and society publications which were sent to various offices of the department and later transferred to the library. The duplicate Government publications are returned either to the issuing offices or to the Superintendent of Documents. Duplicate State experiment station and extension publications received in the

main library are sent to the Office of Experiment Stations library, which returns them to the issuing offices. During the past year the Office of Experiment Stations library returned 57 mail sacks of duplicate station and extension publications to the stations and colleges. Several lists of the more important duplicates of periodicals were prepared and sent to libraries and book dealers. The numbers selected by book dealers realized an exchange value of \$147.30. Fifteen bags of duplicate periodicals and foreign official agricultural publications were transferred to agricultural colleges and experiment stations.

USE OF THE LIBRARY

The use of the library falls under two main heads: (1) The circulation of books and periodicals to readers in response to specific requests, and (2) the reference service, which includes the aid rendered in the use of books, the answering of specific questions, and the search for material relating to a certain subject.

CIRCULATION

Detailed combined statistics of circulation in the main library and the bureau libraries, in so far as such statistics are available, are given in Table 1. The total number of books recorded as circulated was 54,074. Exact figures regarding the circulation of current periodicals can not be given as it is impracticable for the main library and several of the bureau libraries to keep detailed records of this circulation, but from the figures in hand it is estimated that the total circulation of current periodicals is over 250,000. The total circulation of books and periodicals is therefore over 300,000. No records of the reference use are kept either in the main library or the bureau libraries.

INTERLIBRARY LOANS

While the library exists principally for the use of the department, its use is not confined to department workers. Many books are lent to other departments of the Government and to scientific workers connected with institutions outside of Washington. Among Government offices the following have made frequent use of the library during the past year: Bureau of Fisheries, Public Health Service, Bureau of Standards, Geological Survey, Hygienic Laboratory, National Research Council, Patent Office, Tariff Commission, and the United States National Museum.

The number of loans to scientific workers outside of Washington has increased considerably since the war. The distribution of such loans by geographical divisions for the 10 years 1919 to 1928 is shown in Table 2.

The distribution of loans outside of the city, classified by institutions, in the past three years is shown below:

	1926	1927	1928
Land-grant colleges and State experiment stations	1,017	1,195	1,421
Department of Agriculture workers stationed outside of Washington	411	461	525
Colleges and universities other than land-grant colleges	124	112	162
Other scientific institutions	210	220	207
Business firms	48	82	82
Public libraries and miscellaneous	43	88	35
Total	1,853	2,158	2,432

In addition to the 2,432 books lent last year, 216 photostatic copies and 38 typed copies of articles were supplied, making a total of 2,686 loans for the year, an increase of 528 as compared with those of 1927.

As in previous years, extensive use was made of the resources of other libraries both in and out of Washington, to meet requests for books not contained in this library. Grateful acknowledgment is made to the libraries which have given the department assistance in this way. The exact number of books borrowed from other libraries in Washington during the past three years is shown below:

	1926	1927	1928
Army War College			1
Bureau of Education	4	11	1
Bureau of Ethnology	2	1	
Bureau of Fisheries	11	9	16
Bureau of Mines	1	2	2
Bureau of Railway Economics	1		
Bureau of Standards	23	26	77
Carnegie Endowment		2	
Catholic University of America			1
Department of Commerce	2	1	
Department of Justice	1	2	
Department of Labor			1
Fixed Nitrogen Research Laboratory		2	
Geological Survey	49	61	56
Geophysical Laboratory		1	
Hygienic Laboratory	13	6	24
Library of Congress	3,100	3,518	3,357
National Museum and Smithsonian Institution	67	61	61
National Research Council	4	5	1
Naval Medical School			1
Naval Observatory		1	
Pan American Union		2	8
Patent Office	37	37	38
Public Health Service	5	16	24
Public Library	27	25	30

	1926	1927	1928
Shipping Board			1
State Department			1
Surgeon General's office	504	465	763
Weather Bureau	24	55	50
Total	3,875	4,309	4,514

In addition to the books borrowed from libraries in Washington, 71 books were borrowed from 29 different libraries outside of the city.

REFERENCE WORK

There is no satisfactory tangible measuring stick in the way of statistics which can be used in reporting on or measuring the reference work of the library, and, moreover, the keeping of a list of all the reference questions or even the number asked has not seemed practicable either at the main library or in the bureau libraries. Nevertheless, the reputation of a library, which may be considered the intangible measuring stick, is in large proportion dependent upon the success of the reference assistants in meeting the demands upon the library for information and bibliographical assistance. Reference questions asked of the main library and the branch libraries in the bureaus may be divided into at least four classes: (1) Those easily found in well-known general reference works, such as encyclopedias, biographical dictionaries, gazetteers, atlases, etc., (2) those which can be found in special and less well-known reference works, (3) verification of difficult bibliographical references which involve a knowledge of scientific bibliographical tools, and (4) reference questions which can not be found in any general or special reference books and which must be searched for in out-of-the-way places, in chapters of some book, or in articles in periodicals and newspapers not indexed in any of the general or special indexes. Questions of the kind referred to in the two latter classes require considerable experience on the part of the reference assistants and familiarity with the literature of the subjects covered. Outside study and a special interest on their part in the work and aims of the department has, at least to the closer view of the library administrative heads, been productive of real though immeasurable improvement in the character of the work performed.

As in previous years, a considerable number of scientific workers from outside of Washington, including 27 from 13 different foreign countries, have

visited the library to make use of its collections and have expressed pleasure in their completeness and appreciation of the help received through the bibliographical equipment of the library.

BIBLIOGRAPHICAL WORK

Three additions were made during the year to the mimeographed series of Bibliographical Contributions of the library, namely, Nos. 15-17. These will be described below in connection with the descriptions of the bibliographical work of the bureau libraries which prepared them.

In the Bureau of Agricultural Economics library the following additions were made to the mimeographed series of Agricultural Economics Bibliographies:

- No. 20. Bounties on agricultural products; a selected bibliography, compiled by A. M. Hannay. 126 p.
- No. 21. Oklahoma; an index to the State official sources of agricultural statistics, compiled by Icelle E. Wright, assistant librarian, Oklahoma Agricultural and Mechanical College * * * including a list of the unofficial sources of Oklahoma agricultural statistics, compiled by Margaret Walters, reference librarian, Oklahoma Agricultural and Mechanical College. 460 p.
- No. 22. A list of international organizations interested in agriculture, compiled by Katharine Jacobs. 14 p.
- No. 23. Control of production of agricultural products by governments; a selected bibliography, compiled by A. M. Hannay. 85 p.
- No. 24. The poultry industry; a selected list of references on the economic aspects of the industry, 1920-1927, compiled by Louise O. Bercaw. 104 p.
- No. 25. Taxation and the farmer; a selected and annotated bibliography, compiled by Margaret T. Olcott. 190 p.

Five other mimeographed lists prepared by the Bureau of Agricultural Economics library, which were not included in the series noted above, were the following:

- Agricultural relief; a selected list of references, compiled by Louise O. Bercaw. 23 p.
- Freight rates and agriculture; a list of references, compiled by Minna Gill. 36 p.
- Agricultural relief. Bills introduced in the Seventieth Congress, first session. 17 p.
- Long-time agricultural programs in the United States; National, regional, and State, 1921-1927, compiled by Mary G. Lacy. 21 p.
- Oregon, a preliminary list of the sources of agricultural and related statistics of the State, compiled by Lucia Haley, assistant librarian, Oregon State College, in cooperation with the library, Bureau of Agricultural Economics. 12 p.

Thirty-five reference lists were prepared and are available in typewritten form. The library also cooperated in the preparation of seven lists of recent material relating to the literature of rural life for publication in *Rural America*, the organ of the American Country Life Association, at whose request the work was undertaken. The preparation of the lists is a cooperative undertaking of the committee on

cooperative bibliographical aid of the agricultural libraries section of the American Library Association.

The monthly publication of the Bureau of Agricultural Economics library entitled "Agricultural Economics Literature" was published as usual throughout the year with the exception of July and August, 1927.

In the Bureau of Animal Industry library the work on the index of veterinary literature was continued.

In the Bureau of Dairy Industry library a Bibliography on ice cream up to and including the year 1926, consisting of 291 pages, was compiled by Carrie B. Sherfy, librarian of the bureau, assisted by Nell W. Smallwood, junior library assistant. It was issued as No. 17 of the Bibliographical Contributions of the department library. The bibliography was requested by the National Association of Ice Cream Manufacturers. Work was also begun on a revision or supplement to Bibliographical Contribution No. 6, Partial list of publications on dairying issued in the United States, 1900 to June, 1923. The mimeographed list of available department publications relating to dairying was revised twice.

In the Bureau of Entomology library the index to American Economic Entomology is being continued. A check list of publications of the Department of Agriculture on entomology is nearing completion. Lists of new books of interest to the Bureau of Entomology have been prepared each month for the monthly letter of the bureau. In addition, a number of brief typewritten lists on special subjects were prepared, in response to requests.

The third biennial supplement to Department Bulletin 1199, List of Bulletins of the Agricultural Experiment Stations for the Calendar Years 1925 and 1926, was published in December 1927, and the fourth biennial supplement is in preparation. Work is also being continued on the list of circulars of the experiment stations. A list of the publications on soils issued by the State Agricultural Experiment Stations of the United States through 1926 was compiled by Cora L. Feldkamp, librarian of the office, and Catherine E. Pennington, senior library assistant, and was issued as No. 15 of the Bibliographical Contributions of the department library. The cataloguing of the extension publications received prior to 1916 has been finished. Subject lists of extension publications have been compiled on cleaning and home sanitation, games, plays and pageants, songs,

home grounds, house decorations and house furnishing, and home management.

In the Forest Service library brief bibliographical lists were prepared on the following subjects: *Ailanthus* tree, communal forests, forest problems of the Northeastern States, forest resources of the Southern States, forests of Hawaii, nursery practice, red gum, some books on forestry in English, tree surgery, water and light requirements of trees and windbreaks. The list of current literature indexed in the library formerly published in the *Journal of Forestry*, is now issued in mimeographed form every two months.

The Bureau of Plant Industry library continued to issue *Botany—Current Literature*, and *Agronomy—Current Literature*. A bibliography entitled "Author and Subject Index to the Publications on Plant Pathology Issued by the State Agricultural Experiment Stations up to December 1, 1927," compiled by the librarian of the bureau, Jessie M. Allen, was issued as No. 16 of the *Bibliographical Contributions of the department library*, and comprises 251 pages. This list was requested by the American Phytopathological Society in a resolution passed at its annual meeting in 1925. A list entitled "Books for Plant Study," prepared by Alice C. Atwood, was published in August, 1927, by the Wild Flower Preservation Society as its Circular No. 14. A contribution to a bibliography of genetics in relation to plant breeding is in preparation. Work on the bibliography of early horticultural works is being continued by Marjorie F. Warner.

In the Bureau of Public Roads library the mimeographed list of periodical articles and new publications of interest to the bureau, entitled "*Highways and Agricultural Engineering Literature*," was published each week. Much time was also spent in the preparation of a bibliography entitled "*Annotated Index to Articles on Highway Safety and Allied Subjects*," which it is expected will be published in a few months.

LEGISLATIVE WORK

In the report for 1927 the work of the libraries of the Bureau of Agricultural Economics and the Bureau of Public Roads in keeping track of legislative matters bearing upon the projects of these bureaus was described in some detail. This work was heavier during the past year, as the last session of Congress continued until May 29, 1928. After the adjournment of Congress a list of the agricultural-relief bills proposed during the session was pre-

pared in the Bureau of Agricultural Economics library. This contains about 160 items, more than a third of which relate to changes in the tariff. A list of bills relating to grain standards and grain futures was also prepared. A special effort is made to obtain all congressional hearings of interest in the work of the department. More than 50 such hearings were obtained during the past year.

BUREAU AND DIVISION LIBRARIES

A list of these branch libraries and various data in regard to them will be found in Table 3. The statistics of circulation are given in Table 1. Other activities, such as bibliographical work, cataloguing, reference work, translating, etc., are described in the body of the report under these various headings. In addition, mention should be made of certain other affiliated activities of the bureau libraries. The library of the Bureau of Agricultural Economics has charge of what are called the foreign files. These consist of consular reports, commerce reports, market reports, clippings, and mimeographed reports from various foreign Governments received from abroad through the State Department. These reports, after being recorded, are circulated to the various offices of the department to which they are of interest. The total number circulated during the past year was 19,613. In the Bureau of Dairy Industry the library also has charge of the photographic files and the correspondence files. In the Bureau of Entomology and the Bureau of Plant Industry the librarians have charge of the bureau mailing lists. In the libraries of the Bureau of Agricultural Economics, the Bureau of Animal Industry, the Bureau of Chemistry and Soils, the Bureau of Entomology, Forest Service, and the Bureau of Plant Industry records are kept of books and periodicals ordered for the field offices and laboratories. Work in connection with all these activities was heavy during the past year.

TRANSLATING

Many foreign letters and brief articles are translated by members of the library staff, both of the bureaus and the main library. As pointed out in previous reports, increased facilities for translating work are much needed. Some improvement in the facilities was made during the past year in the appointment by the Bureau of Plant Industry of a Japanese translator to fill the position made vacant by the resign-

nation of the former translator. Through the cooperation of the bureau the library has had the help of the translator in handling the files of Japanese agricultural publications. The arrangement made last year in the appointment through the library of a translator whose services can be obtained by the bureaus on a per diem basis has also been found helpful.

COOPERATION WITH OTHER AGRICULTURAL LIBRARIES

It has long been the library's policy to afford opportunity to librarians and library assistants from other agricultural libraries to have experience in this library. During the past fiscal year another assistant from the library of the International Institute of Agriculture, Sigmund von Frauendorfer, worked in the library from July to September in order to become familiar with its methods and resources.

Agricultural Library Notes, a monthly mimeographed publication of the library issued with the cooperation of the land-grant colleges and State agricultural experiment station libraries, was continued throughout the year.

LIBRARY STAFF

The number of permanent employees carried on the staff of the main library at the close of the fiscal year was 30. In addition there were 2 temporary employees. The number permanently employed by the bureau and office libraries was 55. The total number permanently employed in the main library and the bureau and office libraries was 85, distributed as follows: 14 in administrative positions, including the librarian of the department, the heads of divisions in the main library, and the librarians of the bureaus; 37 assistant librarians, junior librarians, library assistants, and junior library assistants; 9 under and minor library assistants; 15 clerical assistants; 1 translator; 6 messengers; and 3 charwomen. In the main library there were 5 resignations and 5 transfers. Of the 10 who resigned or were transferred, 4 left to accept positions in other departments, 5 were transferred

to other bureaus of the department, and 1 resigned on account of health.

In the Bureau of Home Economics library Mrs. Mamie F. Nystrom was appointed librarian on August 22, 1927, to fill the vacancy caused by the resignation of Mrs. Eva Thayer Shively on July 14, 1927. Mrs. Nystrom was formerly assistant librarian of the Bureau of Chemistry. Her position in the latter library was filled by the transfer of Mrs. Margaret Ross Gill from the main library.

Staff meetings, including the staffs of both the main library and the bureau libraries, were held each month from October to June.

The librarian of the department and the chief of the periodical division, attended the meeting of the American Library Association at West Baden, Indiana, in May, 1928. The librarian of the Bureau of Agricultural Economics was appointed secretary of the agricultural libraries section for the coming year.

LIBRARY QUARTERS

The library shelves are again badly crowded. The congestion is so serious that additional space for the library will be a necessity in the immediate future. It will not be possible to wait until quarters for the library are available in the new office building to be built for the department. The collections filed in the basement are in the worst condition, being injured not only because of the crowded condition of the shelves, but also from leakage and heat of overhead pipes.

LIBRARY FINANCES

The receipts and expenditures of the library for the past 10 years are given in Table 4. An increase in the library appropriation for the fiscal year 1930 is urgently needed for books and periodicals, particularly for the purchase of additional copies of periodicals for current circulation. An increase also in the salary allotment is greatly needed for the employment of a bibliographical assistant and for a cataloguer to catalogue the State agricultural experiment station publications. No less urgent is the need for a special library fund for binding.

TABLE 1.—Combined statistics of circulation for fiscal years, 1927 and 1928

Bureau or office library	To individuals		To main library		To branch libraries		Total		Current periodicals	
	1927	1928	1927	1928	1927	1928	1927	1928	1927	1928
Main library.....	20,566	20,219	-----	-----	26,636	26,718	47,202	46,937	(1)	-----
Agricultural Economics.....	13,190	13,327	942	979	50	(2)	14,182	14,306	(3)	(2)
Animal Industry.....	2,131	2,097	208	240	106	91	2,445	2,428	30,661	32,839
Chemistry and Soils.....	7,248	7,676	1,048	998	35	42	8,331	8,716	32,541	36,114
Dairy Industry.....	2,273	2,121	63	91	-----	66	2,336	2,278	20,975	22,099
Entomology.....	3,585	3,062	528	511	16	11	4,129	3,584	5,143	5,062
Experiment Stations.....	(2)	-----	(2)	-----	(2)	-----	(2)	(2)	\$ 40,000	\$ 40,000
Forest Service.....	1,848	2,406	462	482	5	2	2,315	2,890	9,177	8,046
Home Economics.....	(2)	\$ 2,718	(2)	\$ 374	(2)	-----	3,880	\$ 3,092	7,565	6,388
Plant Industry.....	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	40,698	37,620
Public Roads.....	3,233	2,696	432	412	(2)	-----	3,665	3,108	13,972	12,741
Total.....	54,074	56,322	3,683	4,087	26,848	26,930	88,485	87,339	200,732	200,909

¹ No record of the circulation of periodicals is kept in the main library for the whole year, but it is kept for 2 months each year.

² Figures not available.

³ No exact circulation figures are available for the Office of Experiment Stations. The circulation is, however, large, as the office, in connection with the work of the Experiment Station Record, receives all new books and periodicals which are needed for review and abstracting; 860 periodicals are regularly circulated and many more specially requested. The circulation of periodicals is calculated to be not less than 40,000.

⁴ The Bureau of Plant Industry library does not maintain a collection of books, as it is in close proximity to the main library. The circulation of books to members of the bureau is, therefore, included with those for the main library, but circulation figures are available for current periodicals, as this circulation is handled in the Bureau of Plant Industry library.

⁵ For 10 months.

TABLE 2.—Interlibrary loans outside of Washington, D. C., 1919-1928

United States (States, Territories, and island possessions) and foreign countries	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Total
United States: Eastern—											
Connecticut.....	1	7	13	5	5	10	48	53	24	36	202
Maine.....	2	3	1	-----	1	12	8	1	3	1	32
Massachusetts.....	10	37	16	34	37	30	62	62	67	92	447
New Hampshire.....	7	6	9	11	22	12	6	1	21	19	114
New Jersey.....	42	49	89	63	107	75	92	78	68	106	769
New York.....	66	85	81	117	101	136	149	158	188	174	1,255
Pennsylvania.....	10	30	51	37	35	60	75	65	35	108	506
Rhode Island.....	2	12	5	8	-----	1	15	18	4	6	71
Vermont.....	10	3	7	12	11	20	14	19	43	14	153
Total.....	150	232	272	287	319	356	469	455	453	556	3,549
Central—											
Illinois.....	49	23	20	17	13	6	25	44	69	27	293
Indiana.....	4	13	38	7	32	24	23	41	38	58	278
Iowa.....	15	22	72	59	69	82	76	13	38	42	488
Kansas.....	41	22	3	23	15	14	18	11	30	14	191
Michigan.....	9	17	50	24	41	44	39	40	30	63	357
Minnesota.....	63	89	88	44	60	59	70	77	62	47	659
Missouri.....	2	10	6	22	21	30	37	54	32	12	226
Nebraska.....	-----	15	7	7	14	10	25	23	33	26	160
North Dakota.....	6	5	14	10	8	15	10	15	5	15	103
Ohio.....	9	30	32	35	32	89	86	139	187	161	800
South Dakota.....	-----	3	-----	3	-----	1	1	-----	1	1	10
Wisconsin.....	62	2	48	63	35	33	88	67	55	74	527
Total.....	260	251	378	314	340	407	498	524	580	540	4,092
Southern—											
Alabama.....	-----	10	17	5	6	8	3	13	11	4	77
Arkansas.....	9	19	32	21	24	23	20	29	47	51	275
Delaware.....	11	30	21	28	35	84	103	78	75	63	528
Florida.....	17	7	5	13	33	73	80	73	134	107	542
Georgia.....	4	6	12	31	15	14	31	35	43	34	225
Kentucky.....	13	15	13	30	34	49	23	16	24	8	225
Louisiana.....	9	5	5	15	15	10	13	17	13	14	116
Maryland.....	10	21	24	17	66	117	65	115	85	105	625
Mississippi.....	1	-----	4	2	2	5	1	2	18	3	38

TABLE 2.—*Interlibrary loans outside of Washington, D. C., 1919-1928—Contd.*

United States (States, Territories, and island possessions) and foreign countries	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	Total
United States—Continued.											
Southern—Continued.											
North Carolina.....	1	6	26	43	27	48	61	39	64	40	355
Oklahoma.....		1	7	8	5	1	13	15	40	56	146
South Carolina.....	2	2	12	11	15	22	20	30	26	34	174
Tennessee.....	11	10	11	12	33	8	8	7	3	7	110
Texas.....	9	4	21	14	19	19	3	26	17	18	150
Virginia.....	10	19	46	28	38	40	52	47	109	48	437
West Virginia.....	19	10	13	15	13	15	16	30	15	18	164
Total.....	126	165	269	293	380	536	512	572	724	610	4,187
Western—											
Arizona.....	4	4	23		1	11	20	5	20	34	122
California.....	28	43	16	18	29	52	47	54	53	64	404
Colorado.....	5	10	18	9	37	13	9	15	39	31	186
Idaho.....	4	8	1	7	1	4	4	12	24	15	80
Montana.....	17	13	7	6	38	26	17	25	37	26	212
New Mexico.....	7	6	11		1		2		8	2	39
Nevada.....		1		2	1						4
Oregon.....	5	19	53	30	15	6	8	38	35	91	300
Utah.....	8	14	19	22	12	45	28	57	47	90	342
Washington.....	21	12	31	4	7	17	22	39	30	33	216
Wyoming.....	6	4	6	11	3	7	21	3	5	12	78
Total.....	105	134	185	109	145	181	178	250	298	398	1,983
Territories and island possessions:											
Alaska.....		1		1					1		3
Canal Zone.....			1								1
Guam.....	2	1						1			4
Hawaii.....	1						1				2
Porto Rico.....	11	14	32	9	9	20	17	22	13	279	426
Total.....	14	16	33	10	9	20	18	23	14	279	436
Foreign countries:											
Canada.....								24	40	44	108
Cuba.....				1					3		4
Other countries.....	3	1	2	1		5	12	5	2	5	36
Total.....	3	1	2	2		5	12	29	45	49	148
Grand total.....	658	799	1,139	1,015	1,193	1,505	1,687	1,853	2,114	2,432	14,395

TABLE 3.—*Statistics of bureau libraries*¹

Bureau or office	Em- ploy- ees	Books	Pam- phlets	Period- icals current- ly re- ceived	Regis- tered bor- rowers	Registered borrowers to whom period- icals are circu- lated	Shelv- ing	Area occu- pied by library
	<i>Num- ber</i>	<i>Number</i>	<i>Number</i>	<i>Num- ber</i>	<i>Num- ber</i>	<i>Num- ber</i>	<i>Linear feet</i>	<i>Square feet</i>
Agricultural Economics.....	16	² 49,350		1,728	517	145	4,365	4,728
Animal Industry.....	2	⁽³⁾		547	65	69	15	540
Animal Husbandry Division.....	1	⁴ 2,800	⁽³⁾	200	35			
Chemistry and Soils.....	4	10,109		536	304	135	1,770	1,000
Dairy Industry.....	4	630	4,775	358	66	57	180	400
Entomology.....	3	10,557	12,557	804	145	33	⁶ 1,578	1,000
Experiment Stations.....	7	4,021	⁴ 60,458	860	87	53	1,847	1,702
Forest Service.....	1	² 25,217		89	167	78	1,227	1,132
Home Economics.....	2	⁴ 2,000	⁽³⁾	270	49	33	782	841
Plant Industry.....	11	⁴ 200	⁴ 1,100	720	⁽³⁾	166	140	650
Public Roads.....	4	6,439	11,540	371	130	118	1,269	726

¹ The Weather Bureau library is administered separately, with the exception that the books and periodicals are purchased from the appropriation for the library of the department, the sum of \$1,000 being set aside each year for this purpose.

² Includes pamphlets.

³ Does not maintain a collection of books.

⁴ Estimated.

⁵ Figures not available.

⁶ Exclusive of one-third of collection filed in other offices.

TABLE 4.—*Financial statement, fiscal years 1919 to 1928*

RECEIPTS

	Fiscal year—									
	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
Source:										
Library appropriation—										
Salaries.....	\$32 160.00	\$32 160.00	\$32 880.00	\$30 060.00	\$32 660.00	\$32 660.00	\$40 000.00	\$38 680.00	\$54 680.00	\$60 000.00
General expenses.....	18,000.00	18,000.00	22,000.00	21,400.00	25,000.00	30,000.00	30,960.00	29,500.00	29,500.09	24,180.00
Total.....	50,160.00	50,160.00	54,880.00	51,460.00	57,660.00	62,660.00	70,960.00	68,180.00	84,180.00	84,180.00
From department printing and binding fund.....	5,358.21	9,210.70	7,031.20	14,549.59	7,460.64	10,621.26	13,171.04	9,983.30	13,173.75	10,045.07
Main library salaries paid by bureaus.....		1,467.50	5,221.67	7,560.02	10,472.89	12,257.50	15,117.84	16,521.50		
Grand total.....	55,518.21	60,838.20	67,132.87	73,569.61	75,593.53	85,538.76	96,248.88	94,684.80	97,353.75	94,225.07

EXPENDITURES

Books and serials.....	\$7,186.86	\$9,246.05	\$9,439.69	\$9,998.58	\$11,182.48	\$11,138.26	\$13,582.31	\$14,710.31	\$14,750.47	1 \$13,013.46
Periodicals.....	6,139.99	5,231.48	6,039.62	6,353.68	7,005.48	6,916.54	6,937.19	7,184.29	7,517.97	8,841.49
Maps.....		62.04		141.88	172.45	147.37	162.45	169.30	137.88	155.41
Index cards.....	85.25	112.23	178.51	231.16	243.20	1,738.15	1,968.83	404.77	476.86	1,133.24
Furniture, shelving, and miscellaneous equipment.....	604.04	293.16	2,525.94	190.23	177.52	971.06			78.44	108.04
Traveling expenses.....	179.44	48.52	219.72	62.90	13.95	21.51	44.97	42.29	16.32	12.47
Freight, express, and drayage.....	37.75	93.07	56.94	13.07	1,459.67	1,136.98	1,013.01	971.84	21,122.24	21,077.00
Supplies and repairs.....	609.01	539.38	518.50	566.76	566.76	38.89	81.81	85.80	78.87	95.40
Truck service.....				9.87	52.78	99.32	97.80	99.60		
Newspapers.....	29,401.95	29,106.85	27,013.25	30,059.01	32,219.04	31,960.67	39,796.96	38,613.92	54,066.54	59,655.09
Salaries (statutory).....	2,039.00	2,356.00	2,921.35	3,931.62	5,394.35	7,774.99	6,194.51	5,080.00	5,319.96	
Salaries (miscellaneous).....										
Total.....	46,283.99	47,083.98	48,913.52	51,344.44	57,210.08	61,943.74	69,824.84	67,362.12	83,565.75	84,091.60
Printing.....	652.75	348.56	342.34	1,826.01	579.03	577.97	424.47	477.32	327.96	438.25
Binding.....	4,705.46	8,862.14	6,688.86	12,723.58	6,881.61	10,053.29	12,726.57	9,505.98	12,845.79	9,607.82
Main library salaries paid by bureaus.....		1,467.50	5,221.67	7,560.02	10,472.89	12,257.50	15,117.84	16,521.50		
Grand total.....	51,642.20	57,767.18	61,106.39	73,454.05	75,143.61	84,822.50	98,113.72	93,866.92	96,739.50	94,137.67
Credit received for duplicates exchanged with book dealers and libraries.....						954.75	604.35	216.35	633.68	147.30
Gifts.....						12.94	10.75			

1 Outstanding liabilities for books, periodicals, and serials, \$83.40.

2 Itemized as shown on p. 11.

Supplies	Repairs	
	1927	1928
Cleaning and toilet supplies.....	\$124.22	\$104.76
Stationery.....	257.85	107.11
Miscellaneous office supplies.....	289.02	488.76
Binding material.....	95.91	49.38
Total.....	767.00	750.01
Repairs		
Repairs and alterations:		
Carpentry work.....	\$57.49	\$65.43
Electrical work.....	60.04	81.46
Typewriter repairs.....	48.00	20.92
Painting.....	120.91	135.05
Miscellaneous repairs.....	68.80	74.13
Total.....	355.24	326.99

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DEC 14 1928

EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF PLANT INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., August 31, 1928.

SIR: I have the honor to submit herewith a report of the work of the Bureau of Plant Industry for the fiscal year ended June 30, 1928.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. W. M. JARDINE,
Secretary of Agriculture.

WORK AND ORGANIZATION

The Bureau of Plant Industry is primarily a research organization devoted to the investigation and improvement of plant production and plant industries, including fruits, fruit trees, grain, cotton, tobacco, vegetables, grasses, and forage, drug, poisonous, fiber, and other plants. This work includes improvement by breeding and selection; the introduction of seeds and plants procured through foreign exploration; experimentation in methods of culture and rotation systems adapted to irrigation, dry-land, or other systems of agriculture; and investigations in handling, storing, shipping, processing, or otherwise utilizing plants or plant products. Investigations are also conducted upon the injury to crops caused by fungous, bacterial, and virus diseases, and by nematodes, weeds, and abnormal environmental conditions. Campaigns to control or eradicate certain plant dis-

eases are conducted in cooperation with the States concerned. The enforcement of the Federal seed act is the only regulatory activity of the bureau.

Some of the noteworthy results of these investigations during the past year are briefly described in the following pages. A more comprehensive idea of the scope of the bureau's researches may be obtained from the list of articles published by the specialists of the bureau during the year, reporting in detail the progress of their investigations. A list of these publications is appended.

The appropriations available for the work of the bureau for the year were apportioned, as authorized by law, to the several types of work under way, approximately as follows:

Research work	\$3,048,467
Control and eradication work	865,020
Regulatory work	20,338
Total	3,933,825

The work of the bureau has been carried on by the following organization:

Office of the chief	William A. Taylor, chief of bureau.
	K. F. Kellerman, associate chief of bureau.
	H. E. Allanson, assistant chief of bureau.
Pathological laboratory	Directed by the associate chief of bureau.
Mycology and disease survey	C. L. Shear, principal pathologist in charge.
Fruit diseases	M. B. Waite, principal pathologist in charge.
Citrus canker eradication	Directed by the associate chief of bureau.
Forest pathology	Haven Metcalf, principal pathologist in charge.
Blister-rust control	S. B. Detwiler, principal pathologist in charge.
Vegetable and forage diseases	Directed by the associate chief of bureau.
Crop physiology and breeding	W. T. Swingle, principal physiologist in charge.
Cotton, rubber, and other tropical plants	O. F. Cook, principal botanist in charge.
Fiber plants	L. H. Dewey, senior botanist in charge.
Drug, poisonous, and oil plants	W. W. Stockberger, principal physiologist in charge.
Plant geography and physiology	Directed by the associate chief of bureau.

Nematology	N. A. Cobb, principal nematologist in charge.
Seed laboratory	Edgar Brown, principal botanist in charge.
Cereal crops and diseases	C. R. Ball, principal agronomist in charge.
Tobacco and plant nutrition	W. W. Garner, principal physiologist in charge.
Alkali and drought resistant crops	T. H. Kearney, principal physiologist in charge.
Sugar plants	E. W. Brandes, principal pathologist in charge.
Botany	F. V. Coville, principal botanist in charge.
Dry-land agriculture	E. C. Chilcott, principal agronomist in charge.
Western irrigation agriculture	C. S. Scofield, principal agronomist in charge.
Horticulture	L. C. Corbett, principal horticulturist in charge.
Gardens and grounds	J. W. Byrnes, assistant in charge.
Arlington Experiment Farm	E. C. Butterfield, senior horticulturist and superintendent in charge.
Foreign plant introduction	Knowles A. Ryerson, senior horticulturist in charge.
Forage crops	R. A. Oakley, principal agronomist in charge.
Biophysical laboratory	G. N. Collins, principal botanist in charge.

FRUITS

APPLES

CORRELATION OF LEAF AREA AND FRUIT VIGOR

There is a rather striking correlation between the leaf area per apple on a limb and the size and composition of the fruit. It appears that from 20 to 30 leaves are necessary to bring a full-sized apple to maturity. Up to a certain total leaf area there is a correlation between the sugar and acid contents of apples and the leaf area. The determination of optimum leaf areas was made by a study of the fruit on branches that had been girdled. Where fruit was growing on branches not girdled there appeared to be some interrelationship between the foliage at points remote from a given fruit and the growth and chemical contents of that fruit. It was found that the number of fruit buds that formed varied with the number of leaves per apple. Those branches having less than 20 leaves per fruit produced no fruit buds. With 20 or more leaves the percentage of fruit buds increased with the increase in leaf area. These results accompanied the girdling of the branches. With ungirdled branches the treatment had no effect on fruit-bud formation.

SPRAY RESIDUES

In removing arsenical spray residues it was found that wiping the fruit either by hand or by machine was not sufficient to reduce the arsenic to the required tolerance. It became necessary to resort to washing the fruit with dilute solutions of either hydrochloric acid or alkalies, and fairly effective methods were developed by the end of the past season. However, with the later fruit which was held in storage for a time after it was picked and which had developed a waxy coating, unexpected problems presented them-

selves, the wax apparently making it more difficult to remove the arsenical residue, but the use of warm solutions proved fairly effective.

These studies have shown that the acid-washing treatment for spray removal need not cause any increase in storage rots. Submersion treatment and the use of coarse driving sprays have resulted in occasional calyx and core injury, sometimes followed by rots. These injuries have been found to be due in most cases to soluble arsenic in the wash solution rather than to any direct action of the hydrochloric acid. The discovery of this fact made it possible to take very important steps forward in the spray-removal program. It explained the fact that the addition of soda to the rinse water was of no particular value in preventing this type of injury and led to the use of limewater in the rinsing solution in an attempt to render the remaining arsenic again insoluble. It also showed the importance of thorough rinsing with clean water and of daily changing the washing solutions to prevent the accumulation of soluble arsenic. Chemical studies were made of the tissue of injured apples, and the results furnished confirmatory evidence that the real agency of injury was arsenic rather than the hydrochloric acid.

BERRIES

Tests were made of a large number of strawberries selected from the breeding fields with a view to determining their value for making preserves and for crushed fruit, and four varieties have been selected as superior to the commercial varieties now being used. At present there are no strawberry varieties that are entirely satisfactory for canning, although a number of selections have shown superior merit when compared with commercial varieties now in the trade in matters of color, firmness of fruit, productiveness, and high flavor.

One hybrid raspberry variety has been selected as superior for the preserving trade and another as superior for the canning trade, in comparison with commercial varieties, and these selections are being propagated with a view to making them available for wide commercial tests. Cannery, preservers, and commercial growers who have studied some of the selections feel that material progress is being made in this breeding work.

A rather comprehensive study of the effect of fertilizers on the firmness of strawberries was undertaken, particularly with respect to their shipping qualities. While this work is not yet complete, preliminary results indicate that firmness is not affected by even very heavy applications of phosphorus, potash, and nitrogen. However, heavy applications of nitrogen alone appear to cause indirectly a marked increase in the extent of decay of the fruit on the vines. This apparently is due to the fact that the nitrogen stimulates a very heavy growth of the foliage and that, under the influence of the heavy shading from the foliage, organisms that cause the decay of the fruit multiply and spread more extensively than they do under more normal conditions.

Studies of the crown-gall organism (*Pseudomonas tumefaciens*) from raspberries have shown that the organism will remain alive and pathogenic for at least 20 months in sterilized soil. Strains of the organism showing no recognizable difference in morphological or physiological characters showed marked differences in pathogenicity, some failing to produce any galls.

CITRUS

BORON-RESISTANT CITRUS STOCKS

It has been found that some of the citrus plantations in California, especially lemon orchards, have been injured by small quantities of boron in the irrigation water, in the soil, or even in the manure used for fertilizer. In view of this, experiments have been begun to test the boron resistance of various new citrus stocks, some of them wild relatives of the citrus trees and others hybrids that have been originated in connection with the citrus-breeding work of the department. Some of the wild relatives of citrus appear to be resistant to boron and able to make excellent growth when watered with a solution of boron that is strong enough to kill ordinary citrus plants in a few months. One of these

new stocks is the Chinese *Severinia*, which is only remotely related to citrus and can not be hybridized with any of the ordinary citrus fruits. The Australian desert lime is another very promising boron-resistant stock for citrus. It is closely allied to and can be hybridized freely with ordinary citrus plants, and a number of hybrids have already been created.

IMPROVEMENT THROUGH BUD SELECTION

The top-working of healthy citrus trees of undesirable strains in the commercial orchards has continued to receive attention and has given successful commercial results. Thousands of inherently unproductive or undesirable fruiting orange, grapefruit, and lemon trees top-worked to desirable strains during the last few years have come into bearing, and performance records of typical top-worked trees have proved that profitable production has been accomplished through top-working within a period of three to five years.

Some 20 years ago many of the leading growers of the Washington Navel orange in the Southwest were of the opinion that this variety was running out. This belief developed from the fact that the younger orchards were showing an ever-increasing proportion of off-type and undesirable trees. The fruit contained an increasing proportion of off-type and unmarketable specimens, and many of the trees were unproductive. The results of the bud-selection work have demonstrated, both experimentally and commercially, that through the practice of systematic bud selection the propagation of inferior strains can be avoided and likewise that the propagation of desirable productive strains can be insured. As the work progresses, additional bud variations among the standard citrus varieties are being found. For example, a Washington Navel strain has been located which matures two to three months earlier than the normal strain. Another variation has been located which matures two or three months later than the normal. Still another variation on an otherwise normal Navel-orange tree produces fruit apparently similar to the normal strain but which has no navels showing on the exterior. The absence of the navel opening may be an important factor in protecting the fruits from certain diseases.

The bud-selection work has been extended in recent years to deciduous

fruits, but it still remains in a preliminary status. Observations in peach, apricot, plum, and prune orchards in particular have revealed the fact that many apparent bud variations are to be found. The same methods have been followed in this work that were adopted in the earlier years of the citrus bud-selection work in that propagations have been made from many of the variations that have been found.

FERTILIZING

Rather striking results continue to be obtained in some of the citrus orchards in California as a result of applying organic fertilizers, mainly barnyard manure, in furrows 14 to 16 inches deep. This method of application in certain Washington Navel orange groves has been practiced since 1914, and the results continue to be outstanding in the production of heavy crops. Tree conditions have been markedly improved, with respect to both tree growth and productiveness. In many instances in run-down citrus orchards the use of the furrow-manure treatment has brought about a rapid improvement in tree conditions, which has been maintained subsequently through successive yearly treatments. This method, which was introduced into the Southwest and developed in connection with the bud-selection work, is now being used extensively not only in the citrus orchards in the Southwest but also in vineyards, olive orchards, and deciduous-fruit orchards.

PRUNING

The observations and experiments based on the result of citrus-tree pruning investigations continue to emphasize the superiority of very light pruning in comparison with the heavier pruning formerly practiced by many growers. The light pruning now advocated involves the removal of dead wood and the cutting out of certain growth which observation and experience have demonstrated is undesirable.

The lemon growers have finally adopted this practice of light pruning, these growers being the last of the citrus growers to be convinced of the soundness of this practice.

HANDLING AND STORAGE

Various disinfectant washes have been investigated with a view to the determination of practicable methods for avoiding an estimated loss of \$100,000 or more each year from the decay

of citrus fruit in transit from California. A number of disinfectants have been used, including borax, sodium bicarbonate, and some of the stronger alkalies. The treatment with sodium bicarbonate gives good results. Practical details for the use of this material have been worked out.

The methods and temperatures found satisfactory for storing Florida-grown grapefruit have not proved equally satisfactory for California grapefruit. It has been determined that California grapefruit can be stored for a period as long as four months at 55° F. and still be in good condition for market at the end of the period. However, storing at 55° for eight weeks and then holding the fruit for two months at 40° produces a somewhat better fruit than that stored throughout the season at 55°.

The question of temperature for orange holding has become somewhat acute, incident to the increasing exportation of California citrus fruit to foreign countries. It has been found through experiment that the same variety of orange from different sections in California does not behave uniformly in all cases under given temperature conditions. For example, the Valencia orange from some sections of California was stored at a temperature of 32° F. for four weeks with only 2 per cent of low-temperature injury, and at 40° it held for six weeks without injury, but the same variety from other sections showed as high as 10 per cent low-temperature injury when stored at 40°. The Washington Navel orange also behaves differently from the Valencia.

CITRON

Because of a growing increase in requests for information regarding the preparation of citron rind (from *Citrus medica*), studies were undertaken to determine the preserving qualities of our home-grown fruit and to devise practical methods for its curing and preserving. These studies have demonstrated that citrons from California and Florida, when properly selected and treated, result in preserved citron as good as or better than the average imported product. With a probable larger production of citrons in the southern parts of the United States it may be desirable and possible to establish a domestic supply of the preserved rind and thus remove, at least in part, the dependence of American consumers on the imported citron rind.

CANKER ERADICATION

The effectiveness of the campaign for the eradication of citrus canker has been demonstrated in the rapid reduction of infected trees and the thoroughgoing success in preventing epidemics in commercial regions. Alabama, Mississippi, and Texas are now believed to be free from canker, but systematic inspection will be required for several years yet to prevent the recurrence of epidemics. In November, 1927, 85 infected trees were found on two properties in Florida, and it was necessary to destroy approximately 200 grove trees adjacent to the infected trees. Many of the trees on these properties had been injured or partially destroyed by the severe hurricane of September, 1927, and as a result the groves had been neglected by the owners, and the canker had had an opportunity to spread. This, however, is the first serious infection in that State since 1922.

In Louisiana a few scattered infections were cleaned out during the year, but there are a considerable number of dooryard plantings with many infections among them. Owing to these scattered infections, it will be several years before canker can be completely eradicated in Louisiana.

DATES

The best date varieties of the leading date-growing countries of the world are now being tested in the United States. No other country has so many high-class varieties under trial, as other date regions for the most part grow only their own varieties and do not have outside varieties for comparative tests.

Although the situation in this country at present is extremely advantageous from one point of view, that of selecting the best varieties for commercial culture in the different date regions of the United States, there is a drawback in that careful discrimination of the hundred or more varieties being tested is very difficult.

One of the department's date specialists has been giving attention for some years to the working out of a system for distinguishing date varieties by methods used by botanists in the scientific study of plant characters. During the last year this work was continued and supplemented by the observations of a visiting student from the date region of Arabia, so that great progress has been made in tabulating the botanical characters of the different varieties, and it is believed that it

will now be possible to distinguish between date varieties even when the trees are not in fruit. In view of the fact that offshoots of certain rare varieties have been sold for as much as \$100 each in this country and that in some cases varieties of much less value have been mistaken for these rare sorts by uncritical observers, satisfactory methods of identification will prove of great importance to North American date growers.

GRAPES

Many of the important grape districts in California have already become so infested with phylloxera that the vineyards are becoming rapidly depleted, and this insect apparently is spreading with considerable rapidity into sections heretofore uninfested.

Small cooperative test plots are conducted mainly with a view to promulgating the methods and practices of establishing phylloxera-resistant stock vineyards and for testing the better phylloxera-resistant stock varieties under different soil and climatic conditions. Vinifera varieties suited to the different regions of the Southwest are grafted on the phylloxera-resistant stocks planted at these different places.

A particular stock and a particular variety may be suitable for planting under certain soil conditions in a given district, but if that variety and that stock will not make a congenial union when the one is grafted or budded on the other, it is obviously necessary to make adjustments accordingly. There are so many of these congeniality problems that can be worked out only by actual test that progress toward ultimate solution is rather slow.

The nematode problem is also becoming rather prominent in some sections. While the phylloxera is particularly destructive on heavy soils, the nematode is more active on sandy soils. Hence between these two destructive agencies most of the soils may be made nonproductive to the grape industry. An effort is being made to find suitable stocks that are resistant to both the nematode and the phylloxera. A phylloxera-resistant vineyard can be established in one of three ways: (1) By planting bench-grafted vines, (2) by grafting resistant stocks in the field in the spring, or (3) by budding resistant stocks in the field in the fall. The grape investigations that are being carried on have been instrumental in getting vineyardists started in field budding in the fall. This method seems to

possess certain advantages over the other two methods.

Many new grape varieties have been tested in connection with these investigations. As a result, a considerable acreage has been planted commercially to varieties that have proved to be of exceptional merit. Among these may be mentioned the Ohanez, a late storage variety; the Panariti, a dried-currant variety; and the Monukka and the Maraville de Malaga, which are high-quality table varieties. Breeding work has been undertaken with Vinifera varieties, the object being to obtain, if possible, new varieties having more desirable characteristics than those now available. The work is being directed toward obtaining seedless varieties with muscat flavor.

PEACHES

CANNING PROBLEMS

A satisfactory crushed fruit of excellent quality for use in ice-cream making or as pie filler can be made from the eastern commercial peaches by preservation in either of two ways—(1) by the addition of sugar and freezing or (2) by canning and sterilization with or without the addition of sugar. The product preserved by canning can be produced very cheaply, and the fact that it can be distributed like other canned goods gives it considerable promise for both home and commercial use by ice cream and pie manufacturers.

Because of the relation of maturity, texture, and other physical conditions of the fruit in regard to canning, a detailed study of the physical and chemical methods of the processes of ripening of the leading commercial types of peaches has been in progress for three seasons in a number of the extensive producing areas. The results thus far obtained show that climatic conditions during the period of late development and ripening in the peach have a very decided influence upon the chemical composition and rate of ripening of the fruit and that these influences seem to be dominant over any differences due to soil or cultural treatment. These results have a direct bearing on the utilization problems of eastern-grown peaches. With the wide differences noted in the physical and chemical conditions of the fruit under different seasonal conditions, it at once becomes obvious that there are inherent difficulties in the

making of a canned or otherwise preserved product that shall be uniform from year to year. A canned product that is widely variable from season to season will obviously be difficult to merchandise. Apparently it will be necessary to take into full account as far as possible the seasonal conditions and their influence on the fruit in the manner in which it is handled for canning or preserving and in the details of those processes.

A study has been made of heavy losses of canned peaches due to the swelling of the cans in instances in which canners put up unpeeled peaches for pie filling. This swelling was concluded to be due to the presence of sulphur in the cans, the sulphur being carried into the cans in the form of spray residue that was on the skin of the fruit. A method of treating the fruit prior to canning was developed which is effective in removing the sulphur from the skin and thus preventing losses from swelling.

PHONY DISEASE

The phony disease of the peach has increased in Georgia to an alarming extent in recent years, and the growers now realize the great menace of this disease to their industry. Diseased trees are more numerous in the older districts, and the disease has now appeared in nearly all of the newer peach plantings of the State. In 1928, during the months of January, February, and March, 631,000 peach trees were removed in the section of Georgia lying south of Macon. Out of this heavy cutting 50 per cent were phony trees. This left some orchards in such ragged condition that they were removed entirely. The selection and propagation of possible resistant stocks has been continued on a large scale, and about 40,000 grafting operations were performed during the last year. Two commercial orchards totaling 20 acres were planted for the purpose of applying a field test to the resistant stocks produced in 1927. One block of 10 acres was planted on ground from which an orchard containing 99 per cent of phony trees had just been removed. The phony disease is apparently not communicated by buds and scions from diseased trees, but there is much evidence to show that it is readily communicated by root grafting phony roots on the root systems of normal trees. The incubation period under such circumstances is about 16 months.

PEARS

Because of the increasing commercial importance of the pear, there is considerable demand for methods of storing and handling to prolong the season for this fruit. It has been found that under proper handling and when picked at the proper stage of maturity, the storage life of the comparatively early varieties, such as Beurre Hardy and Comice, is prolonged from one to two months by storing at 31° rather than 36° F. The later varieties, such as Winter Nelis and Easter Beurre, will keep from one to three months longer at 31° than at 36°. The best time to pick the pears for storage has been fairly satisfactorily determined by the use of the pressure test.

NURSERY STOCK

Because of the strong growth and vigor of an outstanding individual in a collection of Northern Spy apple seedlings, it was selected for further development. It proved to be an individual which very readily propagates from root cuttings, grows readily and vigorously, and has a considerable degree of resistance to pear blight. It seems also to be noticeably resistant to woolly aphis in comparison with the ordinary commercial apple-stock seedlings. This seedling is now being propagated in sufficient numbers to permit of its being given an extensive test on a commercial scale.

Cherry seedlings, both mazzard and mahaleb, gave good stands from fall planting and developed into good-grade seedlings where they were sprayed with Bordeaux mixture four times during summer. Many of those unsprayed were nearly defoliated in midsummer by leaf spot and matured too small in size to be useful for stocks. The mazzard seed used was mainly from wild trees collected in Maryland. As in preceding years, imported seed gave smaller percentages of germination than the domestic seed. This is probably due to the difference in the way the seed was handled, the domestic seed being kept from drying.

Seedlings of the Bartlett pear made a noticeably stronger growth than seedlings from imported French pear seed. Like the cherry, growth was shortened by leaf spot where the plants were unsprayed.

Experience with the different fruit-stock seeds last year leads to the belief that in the vicinity of Washington fall planting is more desirable than

spring planting and that systematic spraying with Bordeaux mixture for the control of leaf diseases is necessary. Considerable attention is being given to methods of vegetative propagation for apples, plums, pears, and various other stocks. Peaches and apricots do not respond readily to propagation by vegetative methods under any conditions thus far provided for them. In the propagation of the myrobalan plum by various methods there are no appreciable differences in the root systems that develop, whether grown from hardwood cuttings, from root cuttings, or from seed, taproots developing in each case.

CONTROL OF ROTS WITH CARBON DIOXIDE

Studies of the effects of solid and gaseous carbon dioxide upon various fruits and fruit rots have been made under different conditions of transportation and storage. The work has included tests at constant temperatures and in pony refrigerators and refrigerator cars. It has been found possible to subject most fruits to percentages of carbon dioxide sufficiently high to inhibit largely or completely the more serious transportation rots without harmful effect to the fruit itself. The inhibiting action of a particular percentage of carbon dioxide upon the fungi varies inversely with the temperature, and the harmful effect upon the fruit varies directly with the temperature and also with the time of exposure. It follows that the more rapidly fruit can be cooled the less the likelihood of injury from carbon dioxide and the greater the probability of gas inhibition of the rots. Special icing of refrigerator cars with this material in certain tests has been found to improve the condition of the fruit upon arrival.

NUTS

PECANS

Varietal studies of pecans have been conducted in practically all of the important districts in the pecan-producing sections of the country. The results of these studies emphasize the need of improved varieties which are better adapted to the conditions in many of the sections, also varieties that possess greater fruitfulness and resistance to insects and diseases. Cold-storage tests have demonstrated the practicability of carrying pecans over from one season to another by holding them at a temperature of 30° F. By recourse to proper cold

storage the surplus from a heavy crop in one year can be profitably carried over to another season. Cultural investigations also have been conducted. One of the practical results is the development of evidence that the cost of the production of pecans per pound can be greatly reduced by increasing the intensity of cultivation and the quantity of fertilizer and that the quality of the product is likely to be improved by such cultural treatment. Rather extensive studies of the root development of pecan trees indicate that deep plowing in early winter does not appreciably injure the trees. Studies of pecan stocks for use in propagation indicate that seedlings of certain varieties may have some slight advantages over other seedlings. However, as the trees in the experiment attain greater age the present indications somewhat favorable to certain stocks may disappear.

PISTACHE

For a number of years past, investigations have been conducted on a small scale with a view to the establishment of the pistache nut in commercial culture in the United States. The more important varieties grown in the countries bordering the Mediterranean Sea have been introduced into this country, together with some of the wild relatives of the pistache, to be tested as stock plants for the cultivated varieties. It has been found that the Mediterranean varieties grow well in the United States, but in most cases the nuts fail to split open as they ripen. Such unsplit nuts are not salable under present market conditions, and on account of the small size of the pistache nut it is an expensive and troublesome operation to separate the split from the unsplit nuts.

During the last year a reconnaissance of the pistache situation was made in company with an Italian expert who has studied the industry in his home country, and the fact was established that in the San Joaquin and Sacramento Valleys of California the Mediterranean varieties grafted on the Chinese wild pistache as a stock give yields many times greater than those obtained in the commercial orchards of the Mediterranean countries. Since the pistache blooms late in the spring after danger of frost is past and the nuts are the most expensive that reach the American market on a large scale, it is believed that the pistache may be developed into an important crop in this country if

varieties can be found that are adapted to culture under our conditions.

VEGETABLES

BEANS

A survey of large commercial bean-growing areas in the West and Southeast revealed a serious condition in regard to a new or little-known bacterial disease of snap beans which bids fair to exceed in economic importance the well-known bacterial blight (*Bacterium phaseoli*). As western-grown seed is widely sold in the eastern and southern markets, it is of special significance that the disease was found causing serious losses in both the western and southeastern United States. Investigations are being conducted in an effort to determine whether the disease is seed borne.

In breeding for disease resistance two outstanding selections of snap beans for the canning trade were obtained from 580 families of hybrid origin. One is a good bush-type wax bean which holds promise as a canning and market-garden variety, and under serious field epidemics of bacterial blight and mosaic appeared to be remarkably free from disease; the other is a type of Green Refugee which appears to be an improvement of the Stringless Green Refugee now used by the canning trade, and its growth habit is such that it should be of value with mechanical harvesters.

CABBAGE

Trials with various compounds of calcium applied to the soil for the control of cabbage clubroot have shown that ground limestone and air-slaked lime are not reliable. Freshly hydrated lime is much superior to either of these and when applied in quantities of 1,000 to 2,000 pounds per acre (depending upon the soil reaction and the degree of infestation) gives a commercially successful control.

CARROTS

Further investigations of the carbohydrate changes in carrots during storage, covered a sufficient number of varieties of stock and of table carrots to make the results generally applicable as far as carrots stored in bins or cellars are concerned. The behavior of carrots stored in pits still requires investigation.

The work showed that carrots generally do not contain starch as residue

carbohydrate but that they contain a small percentage of other polysaccharides which decrease somewhat during storage. In the absence of starch, the hydrolytic products of which result in an increase in cane sugar in starchy roots and tubers in storage, this sugar, which is the chief carbohydrate of the carrot, undergoes a loss during storage. This loss results in a deterioration of both flavor and nutritive value, although the loss in nutritive value is compensated in part by reason of and by the quantity of glucose formed from the cane sugar.

CUCUMBERS

Since the eradication of wild host plants in the vicinity of cucumber fields was found to be successful in reducing mosaic in the Middle West, this method was tested under eastern conditions by arranging for a demonstration with six cucumber growers near Salisbury, Md. Occasional plants of milkweed and physalis or ground cherry were found, but the principal host plant of mosaic was the common pokeweed, and in some instances the mere removal of a field from proximity to woods, fence rows, and ditches where these host plants were found was sufficient to reduce largely or eliminate the disease.

The season's results showed an increase of 263 per cent over the yield of the preceding year in the six demonstration fields where mosaic was held to a minimum.

LETTUCE

Continued observations have again shown that little transmission of mosaic occurs in the field until the lettuce aphid, which seems to be the only agency concerned in the transmission of the disease, appears in numbers. Infection occurs in 100 per cent of the cases where aphids are used as a means of inoculation; but, as in the case of the cucumber, the insect appears to be only a mechanical carrier of the disease. A single aphid will produce infection after an hour's feeding on a mosaic plant, but it loses its infective power immediately after feeding for a short time on a healthy plant and will not transmit the disease again if transferred to a second healthy plant. When held in a cool place without food, the aphids appear to carry the virus for only about 24 hours.

The strains of lettuce resistant to brown blight—Imperial No. 2 and Im-

perial No. 3—developed by the department and introduced in 1927-28, were used on about 25 per cent of the 24,000 acres in the Imperial Valley of California.

While these strains are well adapted to the Imperial Valley, they are not entirely satisfactory for many other sections. A new resistant strain, Imperial No. 6, which gave some promise of a wider adaptation in field trials during the present season, will therefore be given an extensive commercial trial next season.

ONIONS

American-grown Valencia onions are being successfully produced and marketed in large quantities, mainly in a few sections of certain Western States, but their culture can undoubtedly be extended to practically all parts of the country. One of the chief problems, however, in maintaining the success of the industry is a supply of seed of a strain which remains true to type year after year. At present most of the seed is imported, but preliminary work and observation indicate that the seed can be produced in the United States.

Much the same situation prevails with respect to the Bermuda type of onion, but the most difficult problem in this case is the keeping of mother bulbs over winter.

Storage tests of some of the principal commercial varieties of onions have been carried on, the tests being under high, medium, and low humidities at 32°, 40°, and 80° F. The humidity of the storage appears to be an item of great importance. A storage temperature of 50° with a low humidity appears to be better than 30° with a high humidity. Similar tests are being conducted with other bulbs.

An investigation of the cause of discoloration of onions in new bags has been completed. This trouble was assumed by the trade to be caused by dye in the fabric of the bags, but was found to be due to an alkaline sizing in the fabric, which on becoming slightly moist in storage causes an alkaline reaction in the color pigments of the onion scales, thus producing brownish and greenish black discolorations of the onions in contact with the bag. No softening or decay has been observed in onions showing this kind of injury.

The neck-rot diseases, which are particularly destructive to white onions and onion sets, are becoming less of a hazard to those who, like onion-set dealers, are obliged to store a large

portion of the crop during the winter months. Life-history studies of the causal fungi emphasized the importance of careful and critical handling of the crop at and following harvest, to protect it from inclement weather favorable to the diseases. The use of an artificial drying equipment to supplement natural curing, which has been under trial on a commercial scale for two seasons, has again proved to be the only adequate means so far discovered of insuring against heavy losses when neck rot becomes severe.

PEANUTS

In a recent test it has been found that peanut seed of the Improved Spanish and Valencia varieties when 7 years old gives a germination of 56 per cent and 47 per cent, respectively, for these varieties. Although this germination is lower than is desirable for commercial results, the yields obtained from it compare favorably with the yields of younger seed which had a better germination, the favorable results for the poorer germination presumably being accounted for in the fact that the plants had more room to develop. Selection work with a number of varieties and strains of peanuts continues to show increased gains as a result of this method of improvement. Spacing tests with certain standard varieties show that planting from 4 to 6 inches apart in the rows usually results in the heaviest yields. A method of treating peanut butter that will prevent the development of rancidity and the separation of the oil has been sufficiently perfected to justify the making of an application for a patent for the process, which, if granted, will be dedicated to the use of the public.

POTATOES

SEED STOCKS

While much is being done in strategic sections of the country to improve the supplies of potato seed stock, the fact remains that there is very wide variation in seed stock offered to the trade, even including that which is certified. The variation is mainly in productive-ness of the different strains or lots and in freedom from various diseases. By means of observations on the results in different commercial potato-growing districts of seed stock obtained from different sections, it becomes possible to evaluate the different strains that are offered from different seed-produc-

ing regions and to note those that are unduly infected with disease.

Studies were made at the Arlington Experiment Farm to determine the effect of storage temperatures ranging from 32° to 70° F. on the rest period and dormancy of potatoes. It was found that in the early part of the storage period potatoes stored at the lower temperatures germinate quicker in the germination room than those from the higher storage temperatures, but the results are reversed in the latter part of the storage period. The length of the rest and dormancy periods vary with different varieties. The germination of potatoes held at the lower temperatures is hastened by subjecting them to higher temperatures for one to two weeks before planting. The yield has also been increased by this treatment in comparison with planting direct from cold storage.

In studying the effect of storage on viability, the storage temperatures used range from 32° to 70° F. The potatoes in the experiment were placed in rooms of various temperatures shortly after harvest. The viability is lowered when small experimental lots of potatoes are placed in temperatures ranging from 32° to 36° F. within a few days after harvest. When stored at 50° or higher for a period of two or three weeks and then placed in the lower temperatures, no loss of vitality appears. Moreover, the storage of these potatoes at the low temperatures within a few days after harvest injures their appearance for table use. Under ordinary commercial conditions this injury is not liable to develop. However, during harvest seasons when the temperature of the potatoes and of the storage room is around 32°, or when newly dug potatoes are put directly into cold storage under certain conditions at a temperature around 36° or below, this danger is present.

From 112 selections of Irish Cobbler, Triumph, and Green Mountain varieties grown at the Aroostook farm in Maine in 1927, 6 Irish Cobbler, 2 Triumph, and 6 Green Mountain selections were made for increase in 1928. These selections have shown not more than 3 per cent of disease in the case of the Triumph and Green Mountain in four years, and the Irish Cobbler selections have shown no disease as yet. It is by such rigid selection and subsequent increase of the stocks that the highest grade seed stocks can be obtained, since low-yielding strains and the reduction of the crop due to disease are among the most serious problems with which potato growers have to contend.

DISEASES

Comparative seed-potato treatments for Rhizoctonia of potato, conducted with corrosive sublimate, formaldehyde, and the organic mercuries in Maine in 1927, have shown that corrosive sublimate is more effective for controlling Rhizoctonia and for increases in yield than the other treatments. However, results almost as effective were obtained with some of the organic mercuries and formaldehyde. The organic mercuries were used as an instantaneous-dip treatment. On account of considerably more seed-piece decay in the nontreated controls than in the treated lots, significant increases in yield resulted from treated lots, suggesting the advisability of treating seed potatoes to insure maximum production. The causal agents responsible for seed-piece decay were not determined, but it is assumed that factors other than Rhizoctonia induced this result.

The study of the factors influencing the development of Fusarium rot brought out the importance of suberization and wound-periderm formation in the prevention of rot and also indicated the requisite conditions for rapid development of the protective layer. The importance of handling potatoes during harvest and storage operations with a minimum of injury was disclosed in records of market inspectors, which showed that wounds are the most frequent source of storage rot. Cooling freshly harvested potatoes too rapidly may increase wound rot, because of the slowing down of wound repair. If wounds are properly healed before potatoes are placed in storage and if sufficient ventilation is provided to keep the stock dry during storage, very low temperature is unnecessary to prevent loss by storage rots.

TOMATOES

BREEDING

A very early variety of tomato of the Marglobe type resistant to wilt and blight is much needed by truckers throughout the United States and by canners in New York, Michigan, and other States adjoining Canada. Both pink-fruited and red-fruited varieties of this type have been obtained by crossing Marglobe with the earliest varieties now in use, and considerable progress has been made in their improvement. A few that are best developed will be distributed for field

trial within a year or two and others within two or three years.

Organizations of tomato growers in a few districts where only Globe or other pink-fruited varieties are grown have built up their trade on pink fruits and therefore hesitate to change to a red-fruited variety. There is considerable demand in these districts for a pink-fruited variety of the Marglobe type that will resist wilt and blight. A large number of pink-fruited lines obtained from the original Marglobe cross are now being used to develop such a variety. Although not as yet so uniform and well fixed as the Marglobe, they produce heavy yields of large, globular fruits and afford good material for the development of a pink-fruited Marglobe.

DISEASES

Nailhead rust is the principal tomato disease of the Gulf region and parts of Mexico, particularly the Sinaloa district. It does most damage to the fruits, but also injures the foliage. Spraying and dusting check nailhead rust somewhat, but have never been popular with the growers except for the control of worms; in fact, the growers were unable to control this disease before the advent of the Marglobe tomato. The Marglobe replaced Globe in southeastern Florida in two years after its introduction. It also attracted immediate attention in other parts of the Gulf region and in Mexico and has given excellent results in these areas. It produces heavy yields of approximately rust-free fruits in these rust-infested regions. Moreover, it produces comparatively few puffs. It also surpasses Globe in resistance to drought and in recovery from floods and freezes. An improved shipping strain of Marglobe now being developed in southeastern Florida is already superior to the regular stock except in size of the fruits.

Continued work on the bacterial canker of tomato has disclosed the fact that this disease, which was formerly confined to the Northeastern States, has extended its range to the far South and West, where it has caused large financial losses to commercial growers. Further evidence that the disease is seed borne has been established through field work. It has been found also that plant beds carry the infection over from year to year.

Tomato growers not infrequently allow diseases to destroy their crop because of a belief that spraying delays maturity. Results of spraying and

dusting experiments covering a period of seven years do not support this belief. In fully half of the tests the sprayed or dusted plots were earlier than the controls; in fact, there was no difference in the average earliness of the treated and untreated plots. The fluctuations in earliness were apparently due to differences in the soil and not to spraying or dusting.

SWEET POTATOES

Special attention is being given to a number of foreign varieties of sweet potatoes to determine their merits in comparison with varieties already in the trade. In addition, a considerable number of seedling varieties have been grown from seed from the Virgin Islands and from the New York Botanic Garden, and many of them have exhibited qualities of appearance, yield, and flavor which commend them for further critical study and testing. Selection work with standard varieties has given results of substantial value. In certain cases where selection on the basis of individual hills has been rigorously followed, practical freedom from stem rot has been obtained.

These selected stocks are gradually being placed in the hands of those who are in a position to increase them for commercial use. Productiveness has also been materially improved through careful selection of seed stock. It has been shown that yields by such selection may be increased as much as 25 per cent. It is felt that the greatest single need of the sweet-potato growers is an assured supply of high-quality seed stock.

TRANSPORTATION STUDIES

A comprehensive investigation of the necessity of body icing of refrigerator cars and its effect on transportation equipment has been in progress. From work done with lettuce, cauliflower, celery, and green corn it was determined that body icing in some form is advisable at certain seasons of the year from some regions with all of these vegetables. Likewise, it appeared to be essential in the shipment of green peas and some other highly perishable vegetables when shipped long distances. It was found also that the presence of water in the car from the melting ice caused disintegration of the insulation and that water in the insulation decreased its efficiency. Investigation is being carried on as to the best means of waterproofing car floors so as to prevent damage to the equipment.

A method of precooling cars, which consists of two blowers driven by small motors, has been devised. By properly adjusting these blowers and regulating the openings from the bunkers into the cars it is found possible to lower the temperature of a car of strawberries at the average rate of about 4° F. per hour, the top layer of the load being cooled the most rapidly. With the berries loaded into the car at a temperature of about 65°, which is a common condition, it is possible to precool a load to a good carrying temperature in from five to six hours. This method of precooling is cheap, simple, and easily applied, and the results thus far indicate that it is very efficient.

An insulated pony refrigerator has been developed and tested in comparison with the ordinary type of pony refrigerator in shipping strawberries from Florida. The insulated refrigerator that has been developed weighs about the same as the ordinary pony refrigerator, but it requires considerably less ice in transit, and in the tests thus far made it maintains a lower temperature than the ordinary type. Furthermore, it has certain other advantages, particularly with respect to protecting the fruit against the drip of moisture from the ice pans.

CEREALS

BARLEY

Trebi barley, originally distributed locally around Aberdeen in southern Idaho, gradually spread over the southern part of that State until at present there is practically no other variety grown and every field of Trebi is practically 100 per cent pure. From Idaho it has spread southward into Utah and northward into Montana. This year there was a large acreage in western Canada and a considerable sowing in the Red River Valley of North Dakota and Minnesota. A compilation of the barley yields at all stations has just been completed. Trebi was grown at 25 stations in the United States and was among the three best at 22 of them. It was a superior variety as far east as Ohio and was the leading variety at the Minnesota substations in the Manchuria area. The great promise that it has shown in the East was not expected.

Seed-treatment experiments for the control of the stripe disease of barley indicate that almost as satisfactory control can be obtained with certain chemical dusts as with the best liquid treatments. The dust disinfectants are most

effective, apparently, when the soil-moisture content is relatively high.

CORN

The *Pythium* root rot of corn, which is important in Wisconsin and Illinois, is now known to occur in Kentucky and Louisiana. In general, the disease may manifest itself in the following ways: (1) As a rot of the corn embryo immediately after planting, preventing germination; (2) as a seedling blight after the corn seedlings have emerged; and (3) as a root rot of the plants not otherwise killed, thus reducing the size, vigor, and yield of the maturing plants. Infection takes place at the tips of the rootlets, producing soft rot in the cortex and vascular elements of the rootlets. Further studies of the fungus have led to the conclusion that it is undescribed, and it is being named *Pythium arrhenomanes*. Greenhouse and field experiments indicate promising possibilities for controlling this soil-borne disease through the development of resistant strains of corn.

Corn seedlings attacked by *Diplodia* or *Gibberella* are more readily infected at relatively low soil temperatures, although they are distinctly subject to infection at relatively high soil temperatures. The explanation appears to lie in the type of cell walls formed in the corn seedlings grown at the different temperatures. At the lower soil temperatures a pectinlike substance is formed which not only is readily penetrated by the invading fungi but also is readily digested by them. At the higher soil temperatures the cellulose walls are well reinforced by suberin in such a way that it is difficult for the fungi either to penetrate or to digest them. Numerous strains of corn have been grown in infested soil and held at low temperatures in order to select those strains that are most resistant, but very few strains are able to resist infection at these temperatures. These resistant strains develop cellulose walls that are well reinforced with suberin and so protect the seedlings from infection.

OATS

Iogold, the fifth new variety of oats developed in the cooperative experiments with the agricultural experiment station at Ames, Iowa, was grown on Iowa farms for the first time in 1927. This variety, like Albion, Richland, and Iowar, originated as a plant selection from Kherson. High

resistance to stem rust, combined with the high yield and excellent kernel and straw characters, has made Iogold one of the most promising varieties of oats ever distributed in the Corn Belt. From the cooperative experiments at Davis, Calif., Fulghum appears to be the highest yielding and most promising oat variety for that State. The acreage sown to Fulghum in California in 1928 is approximately twice the acreage grown in 1927. The earliness of Fulghum is its most desirable character under the rather unfavorable conditions for oats that frequently prevail in the Sacramento Valley during the last month of the growing period. Because of its earliness, Fulghum apparently is superior to the Red Rustproof (California Red) variety in most sections of California where oats are grown for grain.

In general, there was a heavy and destructive crown-rust epidemic in Texas, Oklahoma, Kansas, Arkansas, Mississippi, and Alabama. From Mississippi and Alabama reports were received stating that entire fields were virtually destroyed by this rust. Crown rust also caused severe damage to oats in eastern Nebraska, north-eastern Iowa, and in parts of South Dakota, Minnesota, Wisconsin, and Illinois.

The formaldehyde seed treatment satisfactorily controls the loose and covered smuts of oats, but it has the disadvantages of a liquid treatment. In 1927, 10 chemical dusts, some of which had proved fairly satisfactory for controlling the stripe disease of barley, were tested for controlling smuts of oats. The dusts were applied to the seed of two susceptible varieties, Victory and Golden Rain, both of which were naturally infected with Smut. Six of the dusts produced complete control; the others reduced but did not control the smuts.

RICE

It is estimated that in California 164,000 acres were sown to rice in 1927. Of this acreage 86 per cent was occupied by the varieties, Caloro and Colusa, developed at the Biggs Rice Field Station. Fertilizer experiments, in which ammonium sulphate was used on Caloro rice, gave grain-yield increases ranging from 900 pounds from a 100-pound application up to 1,680 pounds from a 200-pound application. For the 3-year period from 1925 to 1927, inclusive, the average increase ranged from 577 pounds when 100 pounds of ammonium sul-

phate was used to 919 pounds when 200 pounds of ammonium sulphate was used. Similar increases for the earlier variety, Colusa, were somewhat less. The increase of rice yields on older lands through the use of fertilizers is a very important development.

A number of the early maturing and midseason varieties from the extensive series obtained in Japan look very promising. The rices from Chosen (Korea) are mostly too early for California conditions and are too weak in straw. Most of the Chinese varieties are too early also, and all of them lodge and shatter badly. The rices obtained from Java and the Philippines were all too late.

SORGHUMS

Dwarf hegari outyielded all other grain sorghums at several stations in the past year. This variety was introduced from the Sudan region of Africa by the bureau and was distributed to farmers about 12 years ago. It is now the leading grain sorghum in the Salt River Valley of Arizona and is rapidly replacing kafir in the Panhandle of Texas. A more recent introduction of hegari from Khartum, Egypt, appears to be slightly more productive than the ordinary Dwarf hegari grown at Woodward, Okla.

The Fargo Straightneck milo, which has been grown in experiments for five years, has equaled the ordinary Dwarf Yellow milo in yield. This variety is somewhat later than Dwarf Yellow milo and is more susceptible to lodging, but because of the erect heads is much more easily harvested by machinery. Fargo Straightneck milo has largely replaced Dwarf Yellow milo in the Oklahoma Panhandle and adjacent sections in Kansas within the last two years.

A new dwarf straight-necked milo which has been named Beaver will be distributed to farmers in Oklahoma for comparative tests in 1928. This variety has erect heads, most of which are fully exerted from the sheath, and usually does not exceed 36 inches in height. These characters make it well suited to harvesting with wheat-harvesting machinery such as the header and combine. Beaver milo has yielded as well as Dwarf Yellow milo in experiments at Woodward, and since it can be satisfactorily harvested with combines or headers without appreciable grain losses, it can be produced at an expense considerably less

than the cost of ordinary Dwarf Yellow milo, which produces nodding heads.

WHEAT

VARIETAL TESTS

The new varieties of hard red spring wheats—Ceres, Marquillo, and Reliance—have been carefully tested in plot experiments. Ceres is the most widely adapted and in 64 comparable plot trials since 1923 has outyielded Marquis by 17.7 per cent. Ceres is resistant to several of the physiologic forms of black stem rust and is adapted in North Dakota and South Dakota, where this disease is an important factor. Marquillo has yielded slightly better than Ceres in Minnesota, and on the average for the State Marquillo outyielded Marquis by 8.7 per cent. In Montana, Reliance slightly outyielded Ceres, and, on the average for the State, Reliance outyielded Marquis by 7 per cent. The Ceres variety will be grown on more than 40,000 acres in 1928. The Marquillo variety is being increased in Minnesota and the Reliance in Montana.

The Redit variety, an awnless hard red winter wheat developed in the cooperative experiments with the Washington State Agricultural Experiment Station, is now in extensive commercial production. This variety is very resistant to bunt, so prevalent in that territory. Some 250,000 acres of Redit were sown in Washington in the fall of 1927. This acreage was mostly in the area which usually produces the most bunt-infected wheat, and it is expected that as a result of sowing Redit the prevalence of bunt in commercial shipments from the Pacific Northwest will be greatly reduced.

The inheritance of susceptibility and resistance to stem rust is being determined in a series of crosses involving Hope wheat, which is very highly resistant, and the varieties Kota, Ceres, and Marquillo, resistant in varying degrees, with certain susceptible varieties such as Marquis and Reliance. Resistance of most of the varieties was found to be inherited as a recessive character, and the high resistance of Hope as a dominant character.

Special studies of the relative resistance to scab of wheat seedlings grown from pure-line strains of Mindum and Marquis wheat indicate that the conditions under which the seed wheat was produced have an important bearing on the degree of resistance of the seedlings from such wheat. The seed

wheat used in these studies was grown in Canada, South Dakota, Wisconsin, and Illinois. The seedlings from the wheat grown in Canada, South Dakota, and Wisconsin were relatively resistant to the attacks of *Gibberella saubinetii*, while those seedlings from the wheat grown in Illinois were distinctly less resistant.

Some indications of resistance have been noted, however, in a few varieties, particularly in Rudy, Illini Chief, Martin Amber, Wheeling, Enterprise, Theiss, and Fulcaster.

Experiments indicate that infection of wheat plants by the wheat nematode may not be limited to the seedling and early rosette stages, as previously supposed. Artificial inoculation of wheat plants has resulted in infected heads even when the nematode larvae were introduced into the upper sheath when the heads were fairly well developed; that is, when the plants were in the early shooting stage.

While previous experiments have shown that the wheat nematode larvae, when kept dry, may retain their vitality for many years, either in the galls or when the galls are opened, experiments in progress indicate that the nematodes from relatively young galls—that is, galls from 1 to 4 years old—are distinctly more virulent than those from galls stored for longer periods. Some infections were noted from galls as much as 9 years old.

BARBERRY ERADICATION

In the eastern States of the barberry eradication area positive control of local epidemics of stem rust has resulted from the removal of the harmful barberries. A material reduction of the stem-rust losses from destructive epidemics in the spring-wheat States has followed the eradication of the common barberry. In many localities in these more eastern States positive control has been effected. In the western States of the area the removal of barberries has reduced the severity and retarded the date of appearance of local stem-rust epidemics. Although stem rust still occurs in damaging quantities in some States, the removal of so many bushes has eliminated the source of much stem-rust inoculum so that the rust in these States is now less severe and its appearance considerably later than in former years.

In addition, the eradication work has checked the tremendous spread of barberries, which, if allowed to continue for another decade, would have

made the growing of small grains in many areas in these States unprofitable if not impossible.

BUNT OR STINKING SMUT

Bunt or stinking smut of wheat was unusually abundant during 1927 in many wheat-growing areas throughout the United States. The rough-spored species of bunt was found principally in the West, as heretofore. The smooth-spored species of bunt, in addition to being found in the Eastern and Central States, as heretofore, also was found in the Pacific Northwest, particularly in Montana, Idaho, Oregon, and Washington. In experiments conducted in cooperation with the California Agricultural Experiment Station five different kinds of copper carbonate were used in comparison with liquid treatments of copper sulphate and formaldehyde on White Federation wheat for the control of bunt. Only one of these completely prevented infection, and this only when used at the rate of 3 ounces per bushel. The liquid treatment with formaldehyde also prevented infection, but the stand was very greatly reduced.

MOSAIC DISEASE OF WHEAT AND OTHER CEREALS

The host range of the mosaic disease of wheat and other cereals was tested by sowing representative varieties of different cereals in mosaic-infested soil. It was found that the disease developed on certain varieties of spelt, emmer, einkorn, barley, Polish wheat, and spring common wheat (Marquis), in addition to winter wheat and winter rye previously known to be susceptible. The results with winter and spring poulard wheat and different varieties of club wheat were doubtful. No infection whatever was noted in nine varieties of oats. Red winter spelt showed unusual susceptibility; 100 per cent of the plants developed a very severe yellow type of the disease. It is of special importance to note that a rosette-mosaic disease has been reported on spring wheat in Egypt. This is the first report of a mosaic disease of wheat outside the United States.

COMBINE STUDIES

Cooperative investigations of combine harvesting were conducted in Virginia, Pennsylvania, Indiana, Illinois, and South Dakota. Combines were used successfully in each of these States. In Virginia and Pennsylvania

the grain losses in harvesting with the combine were slightly greater than in crops harvested with the binder. In the Corn Belt the losses in harvesting with the combine and binder were about equal. In South Dakota, however, where the crop stands longer without lodging, the losses in harvesting with the combine were less than with either the binder or the header.

Wheat is better suited than barley or oats to combine harvesting, because it can stand for a considerable time after maturity before the crop lodges by the breaking over of the straw. Under humid conditions this breaking over may take place in wheat rather soon after maturity, but in the Great Plains the wheat stands for a month or more before going down. Grain varieties grown in the eastern half of the United States seldom shattered when left for two to four weeks after maturity.

Flax which was nearly free from weeds was harvested readily with the combine, but the very weedy fields could be harvested with the combine only with a considerable threshing loss. If harvesting of the weedy fields of flax was postponed until the crop and weeds were fully ripe or killed by frost, then combining was successful.

SUGAR PLANTS

BEETS

Field trials of disease-resistant strains of sugar beets produced by the bureau have indicated the promising value of several strains, and it is believed that the introduction of these varieties may result in greatly increasing the yield of beets in sections subject to curly top and leaf spot. Studies of the use of fungicides for treating beet seed for the prevention of black root and for spraying and dusting beets for the prevention of leaf spot have indicated the effectiveness of several compounds for controlling these diseases and reducing field losses. Agronomic studies relating to thinning and spacing beets have shown that severity of damage from curly top may be decreased by proper spacing and that effective thinning affords a means of reducing losses of seedlings from black-root diseases.

Satisfactory progress is being made with regard to methods for the control of sugar-beet diseases, and it is believed that the results will be reflected in increasing the yields of beets.

CANE

Further study of new varieties of sugar cane introduced during the last few years by the bureau has confirmed predictions as to their value for culture in the cane-growing States. Culture of these varieties is rapidly resulting in rehabilitation of the industry in Louisiana. Value of the new varieties is shown by the fact that 47,000 tons of sugar were produced in 1926 from 128,000 acres of the old varieties, whereas 71,000 tons were produced in 1927 from 73,000 acres planted largely to the new disease-resistant P. O. J. varieties. Approximately 145,000 acres were planted in 1928, almost all of which is in the new varieties, and the production of sugar has been estimated at 175,000 tons.

Imperative need exists for breeding and developing other new varieties more resistant to diseases and more specifically adapted for culture in the United States, and the study of imported varieties and hundreds of new seedlings produced by the bureau has been continued. Several of the seedlings have given good results, and it is believed that some of them will be suitable for commercial planting.

Further study has confirmed the opinion that after having been subjected to frost the new varieties of cane may be left standing in the field and harvested later with less resulting loss of sugar than by the old method of cutting immediately and placing in windrows until milled. Not only are sugar losses reduced, but cost of harvesting and handling is less than by the windrowing method. Study of the effect of low temperatures upon cut cane has given data of value with regard to storing and shipping seed cane.

DRUG AND ORNAMENTAL PLANTS

SAFFLOWER AND HEMP

The introduction of safflower and hemp as oil-seed crops in the small-grain belt of the Northwestern States, which has been under way for several years, will benefit the manufacturers of paints, varnishes, and related products by furnishing additional drying oils to augment the supply of linseed oil, much of which is now obtained from imported flaxseed, and it will provide new crops for farmers in an agricultural region where crop diversification has long been recommended.

About 30 acres of safflower were harvested last year under dry-land farm-

ing conditions with acre yields varying from 5 to 20 bushels. In some localities the crop was almost a complete failure, owing to the cold wet spring and cold weather during the flowering period which unfavorably affects pollination by insects. Under irrigation in Montana an acre yield of 55 bushels of good seed was obtained. Several hundred acres are expected to be grown in 1928 by farmers under contract to linseed crushers at 75 cents a bushel.

A low-growing, high-yielding, bushy type of hemp obtained from Russia, which apparently is well adapted to the established practices followed by small-grain farmers, was grown on a small plot and yielded at a promising rate. In 1928 the plantings of this type of hemp will be increased to the extent that seed is available.

MA HUANG

Interest of the medical profession and scientific workers in the Chinese drug ma huang (*Ephedra finica*) continues, with a more general recognition of its therapeutic value. The fact that this species is not indigenous to this country and the absence of the alkaloid ephedrine in the American species so far examined has emphasized the importance of further investigations to introduce this valuable species in our arid regions.

PERFUMERY PLANTS

Manufacturers of perfumes and related products in the United States have recognized the desirability of a domestic source of some of the important perfume oils in view of the uncertainty of the supply and quality of such products obtained from abroad. During the last season rose geraniums under cultivation at Torrey Pines, Calif., were distilled, and a promising yield of oil was obtained. Fertilizers and irrigation were found to have a pronounced effect on the yield and quality of the oil produced. Samples of oil submitted to the trade were declared to be of excellent quality. At Mount Dora, Fla., similar experiments with rose geraniums have again been begun with a return of more normal economic conditions in that State.

The cultivation of roses for perfume purposes was actively undertaken during the fall at Corvallis, Oreg., in cooperation with the Oregon Agricultural Experiment Station. The flower-producing qualities of a large number of roses are being studied, and a part of

an acre has been planted to one variety to obtain data on production costs, in order to determine whether the flowers can be produced at a cost that permits competition with European producers of rose oil.

ROSES

In the tests of rose stocks, particularly for use in propagating garden hybrid tea roses, the outstanding ones, based on the record of the number of flowers produced, are several forms of *Rosa multiflora*. Of these forms the widely used *R. multiflora japonica* is one of the best. Another form of *R. multiflora* from China has produced plants averaging a little more productive than this well-known stock. Whether its superiority is sufficient to justify its use instead of *R. multiflora japonica* is an undecided question.

Of the new rose stocks, several of which have been tried during the last few seasons, one of the outstanding ones is a form of *Rosa canina* from Germany, called Broog's Thornless Canina. This stock is unusually easy to handle, as it propagates readily from cuttings and is practically thornless at the stage of growth when budding is done. So far it has shown most of the excellent qualities of *R. canina*, with few if any suckers, provided the plants are budded low. The work with rose stocks in California is somewhat similar to the work in the East, with a considerable measure of similarity in results notwithstanding the diverse conditions in the two regions where the work is done. *Rosa dumatorum* has been discarded in the West as in the East, because it has shown undesirable habits, particularly in suckering badly. Under the conditions at Shafter, Calif., Paul's Scarlet Climber seems to give unusual promise as a stock for roses.

BULBS

Each year's experience adds to the knowledge regarding methods of growing and handling bulbs under North American conditions. However, the development of an American bulb industry adequate to meet the domestic needs is a slow process. It is an exceedingly intensive crop to grow. That much time is required to develop a stock of bulbs is apparent when it is stated that it requires from 10 to 15 years to commercialize a lily that may develop commercial merit in connection with the breeding work under this activity.

LILIES

Some of the hybrid lilies already developed at Bellingham, Wash., are very promising, being both handsome and prolific. In 1924 a number of selections of lilies resulting from the breeding work were made the basis of unit progenies that have since been increased to about 1,000 bulbs of all sizes by vegetative propagation. A preliminary study of surface mulches on frosty spring mornings has been made. Surface mulches are of extreme importance to some bulb growers, more especially the growers of lilies. The Pacific Northwest is especially adapted to culture of the lily, but treacherous spring frosts occur in many parts. It is found that the results of the frosts are very much aggravated when lilies have grown up through a mulch. It is advisable, therefore, that all mulches used be removed before the lilies are up and not returned to the beds before the danger of frost is past.

DAFFODILS

In a study of the 150 varieties of daffodils in the experimental stocks under hot-water treatment, followed by forcing and field tests, it was found the last year that a mite (*Tarsonemus approximatus* Banks) has been a potent factor in depressing the vitality of the stocks. Fortunately the hot-water treatment eliminates this organism. This elimination, it is believed, accounts for a large part of the "pepping up" of the stocks which has frequently been noted by European as well as American investigators and bulb growers as one of the results of the hot-water treatment.

HYACINTHS

The culture of the hyacinth demonstrates that bulbs of as good performance as imported stock can be grown in at least two locations in this country. It is considered that the growing of the hyacinth presents no greater difficulties than the culture of daffodils, which is now a demonstrated success.

GLADIOLUS

Among the numerous specimens of diseased gladioli sent in for examination and diagnosis of disease, there have been during the last two years an increasing number of corms affected with a rot caused by a *Penicillium* hitherto undescribed (*Penicillium gladioli* L. McC. and Thom). The ac-

tion of this fungus on the corms, also its morphological and physiological characters, have been studied. Experiments have shown that the fungus is unable to penetrate the epidermis of normal gladiolus corms, but it does rapidly invade the tissues of both mature and growing corms through even slight wounds. The attached corms rot, and in the brown rotted tissues there is usually an abundant production of white to cream-colored sclerotia, less than one-sixteenth inch in diameter. As known at present it is chiefly a storage disease, though infection probably takes place in the field or during harvesting. This disease has been found in corms from such widely separated localities as the Netherlands, California, Massachusetts, Canada, New York, and Ohio and has also been found in *Tigridia* bulbs.

TOBACCO

In a series of plot tests in Maryland extending over a period of three years the results demonstrate that both the yield and the quality of the tobacco crop may be seriously affected by the mosaic disease. The extent of injury is largely dependent on the stage of growth of the plant at which infection occurs. In the case of early infection the yield was reduced as much as a third; whereas the injury in quality was even greater, amounting to about one-half the total value. One of the important factors in lowering the value of the leaf is a type of rust that frequently follows as a sequel to the mosaic disease.

CALCIUM AND MAGNESIUM REQUIREMENTS

At Upper Marlboro, Md., it has been shown that when a highly concentrated fertilizer supplying only the three nutrients—nitrogen, phosphorus, and magnesium (for example, ammonium phosphate and nitrate of potash)—is used as fertilizer for tobacco and other crops on a light sandy soil, very poor growth is obtained, and definite pathological symptoms, including those due to magnesium deficiency, develop. Addition of a soluble magnesium salt to the fertilizer gives marked improvement in growth, but characteristic pathological symptoms, including malformation of the leaf, persist. This result is due in part, perhaps, to magnesium toxicity, but chiefly to calcium deficiency, as such, and is not seen where superphosphate or other calcium phosphate is a constituent of the fertilizer. Addition of both magnesium and

calcium to the concentrated fertilizer, as in dolomitic limestone, gives normal growth without disease symptoms, as does also a fertilizer composed of cottonseed meal, superphosphate, and a potash salt. In tobacco a minimum magnesium content of about 0.2 per cent in the leaf is required to prevent deficiency symptoms, while the minimum calcium requirement appears to be somewhat in excess of 1 per cent.

RELATION OF BORON TO GROWTH

In cultures of tobacco in nutrient solutions and in sand it was found that boron is essential to normal growth of the plant. In the absence of this element growth is markedly reduced, development of the stem being especially affected. The symptoms of boron deficiency are more clearly shown in vigorously growing plants. The first symptoms of injury are seen in the terminal bud. The young leaves surrounding the growing point assume a light-green color at the base, which is followed by death of the affected leaf tissue and of the growing point. The upper leaves of the plant become stiff, brittle, and slightly chlorotic. The roots are brown in color, instead of the normal white, and develop numerous stubby laterals. There is a certain similarity in symptoms of boron deficiency and those of calcium deficiency, but while the former appear in the basal portions of the young leaves the latter are seen in the margins and tips of these leaves. The terminal growing point is commonly destroyed in both cases.

FORAGE CROPS AND GRASSES

ALFALFA

REDUCED USE OF UNSATISFACTORY SEED

The importation of unadapted alfalfa seed has been greatly reduced during the year as a result of the requirement under the Federal seed act that imported alfalfa and red-clover seed shall be stained as a condition of entry. This reduced importation of unsatisfactory seed should in time have its effect on the stands of this crop. The last winter was very severe on alfalfa throughout the Northeastern States, and these losses were especially severe wherever seed of nonhardy varieties was used. In many cases only varieties of the variegated group survived. Although it has been known for some time that only seed of hardy varieties should be used

in this region, the past winter has unquestionably served to emphasize this fact. The present seed-staining requirement affords a means by which farmers may know something of the source of imported alfalfa seed, but the danger from the use of nonhardy domestic seed is fully as great as that from imported seed.

WILT AND WINTER INJURY

The outstanding development in the alfalfa situation during the year has been the heavy winter losses in the States lying east of the Nebraska-Iowa line and north of the Ohio River and the serious losses resulting from the spread of the alfalfa wilt (*Aphanobacter insidiosus* L. McC.), especially in Kansas and Nebraska.

The decline in alfalfa production in Kansas in recent years is undoubtedly closely associated with this disease, and it is probable that the next census will show a decreased acreage and production in Nebraska due to the same cause. This situation is of vital interest, as alfalfa is a basic crop in the agriculture of this region.

Although it has been shown that there is a close connection between winter injury and the incidence of wilt, it can not be doubted that the use of seed of nonhardy varieties and strains has played an important part in the serious situation confronting the alfalfa growers in the Middle West. It is known that several carloads of southwestern alfalfa seed have been sold and seeded in Kansas and Nebraska in certain years, and much of the winterkilling in these States can be traced directly to this seed. In test plots alfalfa from Arizona seed winterkilled from 90 to 100 per cent, whereas northern-grown common suffered only slight damage. At Lincoln, Nebr., and Manhattan, Kans., a strain of Provence alfalfa sown in a variety test several years ago still has a good stand, whereas surrounding plots of domestic alfalfas, such as Grimm, Cossack, and various strains of common alfalfa, have succumbed almost completely to wilt. Another alfalfa that is showing considerable resistance at both these stations, as well as at other points in Nebraska, is a strain of Turkestan alfalfa, though not all alfalfas from Turkestan exhibit this characteristic.

Of the domestic alfalfas, the Grimm and Ladak varieties came through the past winter with the least injury, whereas of the common alfalfa strains, plantings from seed produced in the

Dakotas, stood up better than those from Utah or Idaho seed. There seemed to be little difference in hardiness between plants from Kansas and Utah common seed, though in general the former seemed to survive the winter in slightly better condition. Arizona common killed out almost completely, as did the Hairy Peruvian, which is of all domestic alfalfas the least winter hardy.

In this same northeastern region plants from Argentine, Italian, French, and Spanish seed winterkilled from 90 to 100 per cent. As might be expected, the various lots from any one country showed some variation in resistance to cold, but it was clearly demonstrated that the use of alfalfa seed from the sources mentioned is attended with great risk.

RED CLOVER

USE OF FOREIGN-GROWN SEED

The crop of red-clover seed harvested in 1927 was better than that harvested for several years, but still far short of the country's requirements. As a consequence, the country still depends to a certain degree on imported seed, and studies have been continued on the value of such seed from different sources. While red-clover seed from certain sources can be used in parts of the United States with reasonable satisfaction, it is becoming increasingly evident that none so far tested is fully equal to domestic seed. In the southern part of the clover belt especially, imported clover seed should not be used. While imported red-clover seed from certain sources may produce a crop, the use of any imported red-clover seed is attended with risk. Every farmer should note whether the red-clover seed he buys is stained (and if so, what color), so that he may learn from his own experience what the result is.

TESTING IMPORTED SEED

In order to determine on a considerable scale the value of the red-clover seed imported since the seed-staining requirement went into effect, samples from most of the importations were seeded at the Arlington Experiment Farm and at Ames, Iowa. The plantings of imported lots at Arlington represent 61 importations checked against seed produced in Minnesota, Ohio, and Virginia. With the exception of four lots, every planting of imported red-clover seed failed to show even a fair stand in the spring of 1928. The fail-

ure of foreign red clover to do well at the Arlington farm is due to the fact that they are mostly smooth or nearly smooth, whereas the American type is rough hairy. Most American clover is more resistant than foreign clovers to certain diseases, such as anthracnose, that may seriously affect a stand or may destroy the second growth. It has been found also that foreign red clovers succumb more readily than the hairy American clover to the attacks of leafhoppers. How much of a factor these insects are in the destruction of clover or in the reduction of a stand and crop has not yet been determined, but enough is known to make it certain that the presence of this insect makes desirable the use of domestic rather than imported red-clover seed. That cold in itself is not the determining factor is shown by the fact that foreign seed may be sown in August on the Arlington farm and the plants survive the winter with practically no loss.

In order to obtain records of yields from imported red-clover seed in a section of severe winters, cooperative arrangements were made with the Iowa Agricultural Experiment Station, and a large number of samples taken from importations were seeded at Ames, Iowa, in the spring of 1926. The harvest of 1927 showed that with one exception none of the imported lots gave hay yields even approximately equal to those obtained from Iowa seed. The one exception proved to be American clover the seed of which had been exported and reimported.

COWPEAS

In cooperative variety tests of cowpeas, the Victor and Columbia varieties were again decidedly superior to commercial sorts in yield of both seed and forage. The demand for seed of the Victor, especially in California, where there is evidence of nematode infestation, has been much greater than the supply. The Columbia variety has also proved most valuable as a summer cover crop.

A new and promising line of study was suggested by the discovery at McNeill, Miss., that the cowpea produces hard pork. Studies were therefore commenced to find the most suitable variety for this purpose, special emphasis being placed on a variety of which two crops can be grown in one season. The development of an early high-yielding variety suitable for pasture would be of material help in pork production in the South.

SOY BEANS

Interest in the utilization of the soy bean greatly increased during the year, especially in the possibilities of the crop for oil and oil meal and in the manufacture of food products. Oil mills in Illinois, Indiana, and North Carolina crushed considerable quantities of domestic-grown beans and found ready markets for the oil and oil meal. Prospects are excellent for soy-bean oil mills in Iowa, Virginia, Louisiana, and Mississippi. The demand of the hog-feeding interests for varieties of low oil content to aid in a solution of the soft-pork problem and of the oil mills for yellow-seeded varieties of high oil content has led to more extensive selection work in an attempt to develop such varieties.

About 1,550 new introductions were received from Manchuria, China, India, and the East Indies. Of the new introductions, nearly all yellow-seeded sorts from North Manchuria, a large number of very promising varieties for early grain, pasture, and forage for northern conditions were noted. The introductions from Nanking, China, also showed numerous excellent grain and forage types for the Southern States. Only a few of the very late types from India and the East Indies gave much promise.

The breeding work, consisting of selections from standard varieties and introductions, indicated many very promising grain and forage types, the most outstanding of which was No. 54606-3. In extensive tests this selection was found much superior in grain and forage to any other variety grown in the Corn Belt States, and its seed won sweepstakes at the International Hay and Grain Show and first prize at the Indiana Corn Show. The Mansoy, a pure-line selection from the Manchu, has been found superior to the Manchu and is fast replacing it in the central and southern portions of the Corn Belt. Several of the yellow-seeded Biloxi hybrid selections are especially promising, and sufficient seed was obtained to carry on more extensive tests in the Southern States. Another introduction, the Delsoy, gave excellent results in the upper Mississippi Delta as a high-yielding oil variety. Further work with selections of pure yellow-seeded plants from mottled selections indicated that continued selections of pure-yellow plants will undoubtedly produce pure-yellow lines.

CENTIPEDE GRASS

Centipede grass, introduced by the bureau from China in 1918, has been under test since that time and is now recognized as a valuable addition to our cultivated grasses. In northern Florida it is replacing St. Augustine grass on the lawns because that grass is subject to injury from chinch bugs. These insects do not attack the centipede grass.

One of the characteristics of a good pasture and lawn grass is aggressiveness. This quality in a plant means principally that it is adapted to the soil and climate where it is growing and therefore able to maintain itself in competition with other plants. In a test arranged at the Florida Agricultural Experiment Station to determine the comparative aggressiveness of 11 of the principal Southern pasture grasses, centipede grass spread more than any other, overrunning and crowding out nearly every other grass beside it.

Centipede grass has demonstrated its ability to grow successfully in the Gulf States on soils too poor or too dry for carpet grass or Bermuda grass. Widespread interest in centipede grass has been aroused by its behavior at the different stations where it is under test, and propagating material is now available in commercial quantities.

BROWN PATCH OF LAWN GRASS

Further experimental work on the lawn-grass brown-patch problem has substantiated results obtained during the summer of 1926 in showing that small brown patch can be controlled by several organic and inorganic mercury compounds. With the exception of the sulphide, all the salts of mercury which were tested controlled the disease. The value of these fungicides depends primarily on the quantity of mercury present. The more soluble salts are preferable for obtaining immediate results in the control of large brown patch. In preliminary tests, finely divided metallic mercury also proved to be an effective fungicide against small brown patch.

ENFORCEMENT OF THE FEDERAL SEED ACT

During the fiscal year samples of 1,455 lots of imported seeds subject to the Federal seed act were drawn by the United States Customs Service and submitted to the bureau for examination. Of these, 44 lots, comprising

889,500 pounds, were prohibited entry under the act, as they were found to be unfit for seeding purposes. Of this rejected seed, 425,500 pounds were exported, 71,100 pounds were denatured for feed, and 26,700 pounds of refuse, resulting from the recleaning in bond of rejected seed, were destroyed.

The Federal seed act requires the coloring of all seed of alfalfa and red clover imported into the United States. Seventy importations of alfalfa seed were received, of which 68 originated in Canada and were colored 1 per cent violet. Two importations originated in Turkestan and were colored 10 per cent red. Of the 141 importations of red-clover seed, 3,300 pounds, comprising two lots, originated in Canada and were colored 1 per cent violet. The remainder, 6,437,500 pounds, originated in Europe outside of Italy and was colored 1 per cent green.

During the years 1920 to 1927, inclusive, France was the chief source of red-clover seed imported into the United States. In 1928 less than one-tenth of the imports came from France, while Poland and Russia were the largest exporters.

Section 6 of the Federal seed act makes any misbranded seed shipped in interstate commerce subject to seizure for confiscation. Two cases were reported to the United States district attorneys under this section. One involved the sale of southwestern-grown alfalfa seed as "Idaho-grown seed," and the other involved the sale as "pedigreed cottonseed" of cottonseed that was not pedigreed.

FIBER PLANTS

COTTON

FUNDAMENTAL IMPROVEMENTS

Constructive changes in the cotton industry, as projected and demonstrated through the work of the bureau, are gradually becoming recognized and are resulting in many demands for more general application. As the improvements are of a character to require the cooperation of entire communities of cotton growers, a greater extent of popular understanding and leadership must be reached before a general application of the community plan of production can be expected. As soon as the underlying facts of production are sufficiently recognized and community cooperation developed, it is possible to change the basis of production from the usual condition of mixed and mongrelized seed stocks to regular supplies of pure

seed, so that all of the farmers of an organized community or district can produce fiber of the same character. Production of cotton in one-variety communities is a means of practical standardization of the crop in the fields, which reduces and simplifies the problem of commercial classing. With uniform conditions of production and pure stocks of seed, the best assurance is afforded that the cotton is uniform in the bales in the essential qualities of length and character of staple. With the entire product of a community placed on a higher plane of quality and uniformity, higher limits or flat prices for whole communities can be obtained by the assurance of good cotton of even character in commercial lots.

GROWTH STUDIES

Detailed comparisons of growth and development of varieties of upland cotton have been made for several seasons at Greenville, Tex., in relation to the time of planting and the effects of different spacings. The germination and early growth of seedlings were more rapid in the later plantings, the intervals between planting and appearance of the first squares were more than 58 days in April plantings, but were reduced to 40 and 30 days respectively, in the May and June plantings and to 19 days in very late plantings, in July and August.

The maturation period of the bolls was little affected by the date of planting, but lengthened with the advance of the season. A slightly longer period to opening of the bolls was found in rows that were not thinned, in comparison with plants spaced to 12 inches. The rates of growth and development of fruiting parts did not show significant differences in the series of five upland varieties compared, which included Kasch, Mebane, Lone Star, Acala, and Kekchi. The formation of fruiting branches along the main stalk of the plants is much more rapid than the formation of flowers along the branches, so that varieties with a stronger growth of the main stalk have an advantage in earliness.

Five years of systematic spacing experiments at the United States Cotton-breeding Field Station, near Greenville, Tex., have been conducted to determine the effects of seasonal conditions in relation to spacing on the "black-land prairies," one of the principal regions of production. Precautions of repeated comparisons are observed, with the experiments subdivided so that only two

spacings are compared in each series. Each spacing is represented by several alternate 4-row blocks, the rows divided into short sections, and each section of each row picked and recorded separately. By this method the variations of field conditions are shown and numerous direct comparisons of the different spacings are afforded, so that the results of each test are made as definite as possible. Spacings of 12 inches and under were tested, and different methods of thinning were compared with one or more plants in each hill. Many of the experiments showed only slight differences in the yields of different spacings, but most of the definite differences were in favor of the closer spacings. In several of the experiments the cotton that was not thinned, with the plants averaging only 2 to 4 inches apart in the rows, gave higher yields than rows that were thinned, showing that under some conditions the chopping of cotton is an unnecessary operation that may be omitted to advantage.

PRODUCTION IN IRRIGATED VALLEYS

Cotton is being grown in several irrigated valleys of western Texas, New Mexico, Arizona, and California under a wide range of conditions, including the extremes of heat, dryness, and heavy, impervious soils. Large yields and excellent fiber are obtained under favorable conditions, but the cotton is injured and the quality of the fiber is impaired where stress conditions are severe. The injuries are shown commonly in the wilting of the leaves, in checking the growth of the plants, and in the blasting and shedding of flower buds and young bolls. Bolls that are too large to shed are also damaged and stunted. Many of the seeds are aborted, and the fiber does not develop normally, but may be very short and weak. Also good cotton may be damaged by long exposure or by careless ginning. To avoid market difficulties with irregular cotton, more careful handling of the crop is needed, and greater discrimination should be practiced in buying, to take account of the effects of different conditions in the fields. The reputation of the irrigated cotton will suffer as long as the commercial lots are irregular.

NEW TERRITORY

An extensive new area of production is being opened in the plateau region of northwestern Texas, where cotton

undoubtedly can be grown more cheaply than in many of the older producing districts. On account of the limited rainfall, a relatively small and precarious production has been expected from the Texas Plateau country, but the rainfall requirement is less under the high-altitude conditions, and the boll weevil is not present. This new development brings many additional problems to the cotton industry, not only problems of adjustment to conditions of production in the new area but also problems in other areas which are affected by so large an addition of new competing territory. Cotton already has been displaced in some of the more humid districts of the former Cotton Belt, and the outlook in other districts will depend to a great extent upon the use of better varieties and methods of production, especially in districts that have favorable conditions for the production of fiber of premium quality and length of staple. A regular production of fiber of good quality affords the best assurance of a favorable market status for any community of cotton growers.

ROOT ROT

Studies of cotton root-rot injuries have been continued in Texas and Arizona. Experiments with clean fallows have led to recognition of deep-seated infestations of the root-rot fungus on buried stumps and tree roots, dead for many years. These findings are important in relation to the possibility of eradicating the fungus that causes the root-rot disease.

PIMA SELECTED STRAIN

The selected strain of Pima cotton, provisionally designated Pima 5-3, has proved to be at least equal in productiveness and earliness to the commercial stock of this variety, and it has longer and stronger fiber. A spinning test of the two kinds of cotton showed 19 per cent difference in breaking strength of the yarn in favor of the new strain. Plantings of 2,000 acres to the Pima 5-3 variety, satisfactorily isolated, were made in 1928, to provide seed for general planting in the Salt River Valley in 1929.

Comparison has been made of the relative ability of seeds of Pima cotton (Egyptian type) and of upland cottons to germinate and to complete the seedling stage of growth on more or less saline soil in southern Arizona. The results indicate that it is easier to get

a stand of Pima than of upland cotton under these conditions.

Tests of Pima cotton grown in the Salt River Valley, Ariz., during three successive years, on land recently in alfalfa, as compared with cotton of the same variety grown on land that has been continuously in cotton during four or more seasons, have shown consistent superiority in the size of the bolls in favor of the alfalfa rotation. Comparative tests at the United States Field Station, Sacaton, Ariz., have shown that cotton when frequently rotated with alfalfa heavily outyields cotton grown continuously on the same land.

ABACÁ

Abacá (Manila hemp) is the most important fiber used in cordage. Heretofore this fiber has been produced only in limited areas in the Philippine Islands. After a great many futile efforts during the last 30 years abacá plants were brought from the Philippine Islands to the Canal Zone in 1925 and are now growing in the Canal Zone, Honduras, Panama, Columbus Island (Panama), and Trinidad. Fiber of excellent quality has been produced, and in one place 50 acres have been set out.

FIBER FLAX

The results of a trial with fiber flax at the mountain branch station at Swannanoa, N. C., near Asheville, in 1926 could not be used as a basis for definite conclusions because the rainfall was very much below normal. The trial was repeated with an acre of fiber flax in 1927. The rainfall was still below normal, but a very good crop of flax was produced, averaging 28 to 30 inches in height and comparing favorably with fiber flax in eastern Michigan and Ontario. A large sample of the straw was sent to the fiber-flax field station at East Lansing, Mich., where it was retted and scutched, yielding fiber of very good quality. The results of this experiment indicate that in normal years conditions in the upper part of the Piedmont section are favorable for fiber flax.

HEMP

The tendency toward overproduction of hemp continues. The theory that increased production of hemp fiber would stimulate wider use and consequently a larger market has not worked in practice. It has been found best to keep the acreage in balance with the

demand. There is practically no importation of dew-retted hemp, so the domestic production supplies the demand for this type of fiber in North American mills. Likewise there is no foreign market for American hemp. Data on the production and consumption of hemp in previous years is compiled and used as a basis in anticipating the demand. This information is given to every hemp grower. Full information regarding supplies and demand furnished to growers, dealers, and consumers has resulted in a very stable market with the least price fluctuations of any of the textile fibers.

RUBBER PLANTS

TROPICAL TREES IN FLORIDA

Large areas in southern Florida remain to be utilized, and a wide range of rubber possibilities is being shown in the experiments at the Chapman Field Plant Introduction Garden, Miami. Most of the better known types of tropical rubber trees are represented, with favorable indications of growing to normal maturity under the Florida conditions. The series includes the Hevea or Para rubber tree of Brazil, the Central American rubber tree (Castilla), two species of Manihot from South America, two African rubber trees (Funtumia and Mascarenhasia), two species of Alstonia from the East Indies and Australia, several species of Ficus, and many vines, shrubs, and smaller plants that contain rubber. The Hevea and Castilla trees at Chapman Field have not reached the flowering stage, but Manihot, Mascarenhasia, and Alstonia have already flowered and seeded. New generations of seedlings are being grown, for breeding and testing under different conditions. Hevea and Castilla trees have grown to mature age at other places in Florida, Hevea at Palm Beach and Castilla at Ritta, on the south shore of Lake Okeechobee.

Tolerance of rubber trees to frost and cold weather in southern Florida was practically demonstrated for the Hevea or Para rubber tree of Brazil and several other tropical rubber trees during the repeated cold periods and a minimum temperature of 28° F. experienced in the winter of 1927-28.

GUAYULE IN CALIFORNIA

The cultivation of the guayule plant (*Parthenium argentatum*) is one of the possibilities of producing rubber in the United States that is now receiving

attention. The plant grows wild in northern Mexico and to a limited extent in western Texas. Experimental plantings on a practical scale made by a private company in several localities in Arizona and California leave no doubt that the plant can be grown in large quantities if remunerative prices are assured. Processes for extracting and refining guayule rubber have been applied extensively to the natural product in Mexico. The experiments in California are now being increased in the district of Salinas, near Monterey, and contracts have been made with farmers for growing guayule on a profit-sharing arrangement, as with sugar beets. The company undertakes to erect a factory for extracting the rubber, raises and transplants the seedlings, and advances a part of the cost of production during the period of growth, which covers four or five years.

OTHER NATIVE PLANTS

Other species of native plants are being found to contain rubber, and the habits of such species are being studied from the standpoint of cultural characters and requirements. One of the native rubber plants of southern Florida, growing wild at the Chapman Field station, near Miami, is a member of the same genus (*Sapium* or *Stillingia*) as the so-called "virgin rubber" of the Andes. Many other *Sapium* species in South America are reported as producing rubber and might be expected to thrive in Florida. Two species of *Sapium* are already considered as naturalized in the United States, a South American species, *Sapium glandulosum*, near Pensacola, Fla., and an Asiatic species, *S. sebiferum*, the so-called tallow tree of China, in the vicinity of Charleston, S. C. Rubber has also been found in a native herbaceous plant (*Pyrrhopappus* or *Sitilias*) on James Island near Charleston. It is similar to the common dandelion, which also contains rubber, as do several of the common milkweeds, dogbanes, sparges, and various plants of the lettuce group. Even among our native flora it is possible that species or varieties may be found that could produce special quantities or qualities of rubber and change the future of the rubber industry.

FOREST-TREE DISEASES

EUROPEAN LARCH CANKER

The European larch canker, caused by the fungus *Dasyscypha willkommii* (Hartig) Rehm, is potentially the

most dangerous forest-tree disease that has ever appeared in North America. It is known to have been in Europe for at least a hundred years and is believed to be native there. It prevents the cultivation of European larch in many localities and makes it undesirable in others. It is one of the principal factors, if not the principal one, that has led in Europe to the substitution of exotic conifers in reforestation in place of the native larch. The disease is of the same type as chestnut blight, which it strongly resembles in many ways.

The disease was first discovered in North America at Hamilton, Mass., on European larch, in May, 1927. Here and elsewhere there was found abundant evidence of former importation of larch and other susceptible hosts from European nurseries. Later it was found that this disease was also attacking tamarack, Douglas fir, and western yellow pine quite as seriously as European larch, and Japanese larch to a limited degree. Still later suspicious cases on tamarack were located in Maine and Vermont. Recently a serious outbreak of what appears to be this disease on Douglas fir has been found near East Greenwich, R. I.

The disease is to be looked for in any place where trees of the susceptible hosts which were imported from Europe have been planted. The disease has not so far been found outside of New England, but it has been looked for carefully only in limited areas of New York and Pennsylvania.

This presents the unusual spectacle of an introduced disease established on the Atlantic coast, but menacing essentially Pacific coast and Rocky Mountain species. The Douglas fir ranges from British Columbia to Mexico and east to Colorado. Western yellow pine occurs within the same approximate limits, but extends eastward to central Nebraska. These are two of our most important timber trees, representing enormous values, and are the essential species to be defended against this disease.

CHESTNUT BLIGHT

In addition to the agricultural exploration of many foreign regions, for example, Canary Islands, French Guinea, west coast of Africa, Sumatra, east coast of Africa, and Madagascar, large increases of new plant material are now being tested in the various regions of the United States. Special attention has been devoted to blight-

resistant chestnuts and related crops, and a specialist is now in Asia searching for blight-resistant chestnuts. Unfortunately, the nut crop of the forest chestnuts was a complete failure in Japan last fall, so that very few nuts of this type were obtained. However, nuts and scions from most of the horticultural varieties in Japan have been imported, and grafted scions of these Japanese varieties are now being grown under quarantine conditions at Bell, Md.

Special efforts have been put forth to establish small orchards of blight-resistant chestnuts in the Eastern States where blight has destroyed practically all of the native chestnuts and formerly profitable chestnut orchards. The main effort during the year was applied to the distribution of the Chinese hairy chestnut, *Castanea mollissima*, of which about 2,100 were distributed in blocks of one-eighth to 1 acre. Several new strains of this chestnut were received, grown, and distributed. Correlated with tests being made through means of collaborators, plantings of about an acre each have been established at three of the bureau's plant-introduction gardens, namely, Chico, Calif., Bell, Md., and Savannah, Ga.

The study of the tannin content of dead chestnut trees, in cooperation with the chemists of the chestnut-extract plants, has been completed, and the results confirm the preliminary indications already reported. The reduction in tannin content and in specific gravity of dead trees from that of the green check trees from the same locality was found to be much less than had been expected. There is every reason to suppose that many of the chestnut-extract plants will be able to continue to operate on dead chestnut for many years, even though most of the chestnut stands from which some of the plants draw their supply of wood are already killed and there will be no new growth of merchantable size of the American chestnut.

CORYNEUM CANKER OF CYPRESS

Complaints received from time to time concerning the dying of branches and whole plants of the very widely planted native Monterey cypress in California have resulted in investigations that show the presence of a serious and heretofore undescribed fungous disease, to be known as coryneum canker. The disease also attacks and kills Italian cypress, which is planted to a large extent in

California though it is rather high priced. The origin of the disease is unknown, but it is very destructive and seems to be gathering headway. Monterey cypress is not only important as an ornamental but is valuable in many localities as a windbreak.

DOUGLAS-FIR SEED TREES

Consideration of the knowledge of decay in Douglas fir gained in the last 10 years leads to the conclusion that it is sound temporary practice in the Douglas-fir region during the transition from virgin to regulated stands to leave decayed trees for seed trees. In general, it is not sound practice to use diseased trees of any kind for seed trees, as they may transmit susceptibility to disease with their seed. But it has been found that the heart rots of Douglas fir become serious only after the tree has attained a certain age, and the future stands of Douglas fir are certain to be harvested before they attain the dangerous age. Leaving a decayed tree for a seed tree saves the cost of a merchantable one. Most of the seed trees would be a complete loss by the time of the next cutting, on account of the slash fire following logging, wind throw, or death from the shock of exposure due to the sudden removal of the remaining stand.

DETERIORATION OF WIND-THROWN TIMBER

An extensive and remarkable wind throw occurred in the Olympic Peninsula, Wash., on January 29, 1921. Except for 1925, yearly observations have been made on the down timber at the end of each summer succeeding the windfall. In 1927 all the data collected up to and including 1926 were analyzed. It was found that western hemlock and Pacific silver fir had deteriorated very rapidly, followed by Sitka spruce, whereas Douglas fir and particularly western red cedar had deteriorated slowly. For the first three seasons most of the loss was occasioned by ambrosia beetles and blue stain in the sapwood. From and after the fourth season, decay became important, so that by the summer of 1926 the sapwood of all species had been virtually destroyed, and in addition considerable heartwood of Sitka spruce, Pacific silver fir, and western hemlock had been rotted. This was shown by comparing the percentage of decay and the percentage of sapwood, which were determined for each species. Decay was retarded by the high moisture content of the wood in the down trees, result-

ing from the normal heavy rainfall in the region.

In addition to the decay there was the loss of timber broken in falling and remaining in stumps. However, by far the greater part of the total loss, except in western red cedar and Douglas fir, had resulted from decay. From the standpoint of utilization, western hemlock and Pacific silver fir were already a complete loss, and Sitka spruce would be so in three or four more years except for the very large trees, whereas Douglas fir and western red cedar, especially the latter, would afford merchantable values for a long time.

WOODGATE RUST

Since last year's report very little additional work has been done on Woodgate rust. There has been little scouting, but so far as known the disease is still confined to the State of New York. The results of maturing inoculations indicate that besides its usual host, Scotch pine, it can also attack Monterey pine, loblolly pine, Virginia pine, slash pine, and western yellow pine. The slash pine of the Southeastern States is an important source of both timber and naval stores; loblolly and Virginia pine, while of limited distribution, are not unimportant sources of timber and are being increasingly used in reforestation; and western yellow pine is one of the most important forest trees of North America.

WHITE-PINE BLISTER RUST

The natural spread of white-pine blister rust during the last year has brought about two important changes in the situation. In the East the disease was found on *Ribes* in 16 additional counties in Michigan, and in Pennsylvania its known distribution was increased from 5 to 37 counties scattered throughout the State. The increasing spread of the disease in the Lake States and its southward sweep through Pennsylvania indicates the need for immediately enlarging control activities to protect adequately the white pine in the Lake States and Appalachian regions.

In the West the rust has periodically extended its range since its discovery in 1921. The disease is now established in the main western white-pine belt of the Inland Empire (western Montana, Idaho, and northeastern Washington) and in northern Oregon. The intensification of the rust in the Inland Empire and its appearance in the sugar-pine region of Ore-

gon and California is certain to occur within the next few years.

The joint program that is being carried on in cooperation with the New England States and New York is rapidly establishing control on the estimated 8,221,167 acres of white pine in this region. Initial protection against the disease has been accomplished on about three-fourths of the pine acreage, at an average eradication cost of 21 cents an acre. In the prosecution of this work more than 800,000 acres are annually freed from *Ribes*.

Control experiments and investigations are rapidly bringing about the development of thoroughly practical control measures for the western white-pine region. These consist of hand-pulling methods where *Ribes* occur scatteringly and the use of chemical sprays applied with specially developed portable power pumps where they occur in dense concentrations. The location and abundance of both host plants, the potential blister-rust danger on pine lands, and the factors governing practicability of control and estimates of the cost of applying control measures have been determined for much of the western white-pine region. Similar experiments and investigations are under way in Oregon and California to develop practical control measures for the sugar-pine region.

The European or cultivated black currant (*Ribes nigrum* L.) is a major factor in the long-distance spread and establishment of the rust, and its complete elimination from white-pine regions retards the spread of the disease. This introduced plant is of small economic importance. It has been eradicated in Montana, Idaho, Oregon, eastern Washington, and the northern half of California. The States of New York, Massachusetts, Michigan, and Rhode Island are taking steps to accomplish its systematic eradication, and it is expected that other States where the white pine is an important forest ornamental tree will do likewise.

DRY-LAND AGRICULTURE

The investigations in dry-land agriculture have been productive of a vast store of basic data on the possibilities of crop production on the Great Plains, and to this knowledge additions are constantly being made. To reduce the cost of production of farm crops and at the same time increase the yields and the quality of these crops seems to be the most feasible way, if not the only way, of relieving the present agricultural condition. A part of

this can be accomplished by crop rotation and the proper choice of crops. The results indicate that a rotation system that includes corn is the most profitable in the northern Great Plains region. The growth of corn reduces the cost of production of other crops and compels the keeping of livestock to consume it. This balances the farming system and adds stability to the farming structure.

One of the most important objects sought by the rotation of crops and by tillage methods is the prevention of the growth of weeds. Corn is very effective in this regard, and the problem of its tillage is usually the problem of weed destruction. The success or failure of the system of farming that is adopted will depend largely upon how efficiently it prevents the loss of soil water by preventing the growth of weeds.

These investigations have shown that the vegetable garden is a valuable asset to a dry-land farm. The yields are somewhat smaller than those obtained in more favorable sections, but this may be offset by planting larger areas. The spacing should be wider, and the garden should be so arranged that horse labor and machinery may be used as much as possible. It is not easy to grow good fruit in most of this area, but experience shows that if a suitable site is chosen, hardy and adapted varieties planted, and the plants given proper care, the Plains farmer will be well repaid for his efforts in this direction. Some sections of the southern Plains appear to be especially well adapted to the growth of grapes.

Through cooperation with farmers in planting shelter belts on their farms since 1916, it has been shown conclusively that it is possible to start successfully a planting of trees on the average upland site on the northern Great Plains. This work is being extended into the central Plains through a station at Cheyenne, Wyo.

EFFECT OF LIGHT PERIODS

The effect on plant growth of short alternating periods of light and darkness has been studied during the year. A number of plants of both the long-day and short-day types have been grown with the same total daily illumination, namely, 12 hours, but with the illumination discontinuous; that is, broken into shorter periods alternating with darkness, with the result that growth has been markedly affected. As the alternations of equal light and

darkness are progressively shortened, there is a corresponding reduction in growth until with alternations of about one minute very poor growth is obtained, the plants become markedly chlorotic, and in some cases they soon die. As the alternations are further shortened, however, there is improvement in plant growth, until approximately normal development is obtained with alternations of about five seconds. Thus, with light of the same intensity and composition and with the same relative duration of light and darkness, plant growth is greatly modified by the absolute duration of the unit of light exposure. As regards flowering and fruiting, no important selective action of the different light-darkness alternations has been observed. In this particular both long-day and short-day plants behave as though exposed to a long day.

PAPER MULCH

Experiments with impervious black paper mulch on various crop plants at the Arlington Experiment Farm indicate a definite and appreciable stimulation with most crops. Taken in conjunction with the results of the trials of the three preceding years, there seems to be a reasonable assurance that such a mulch can be relied upon to promote the growth of crop plants in the eastern United States.

The economic adaptation of paper mulch to crops and conditions in this country, however, appears to depend largely upon the development of suitable papers at a cost commensurate with the durability essential for the production of any given crop. The use of a heavy type of paper such as characterized these trials appears to be feasible only when its serviceability extends over a period of years, as in pineapple culture. Such a paper, now arbitrarily classed as type B, appears to be of sufficient promise to warrant wide experimental trial with various perennial crops such as small fruits, nursery stock, and young trees set into permanent orchard plantings. Its use for annual crops appears limited to home gardens. The plant response to a light type of paper, classed as type A, designed to have a durability sufficient for the production of a single crop, is included in the present research.

In addition to the study of the special utility of various papers for use with particular crops further investigational work is being carried on relating to

the biophysical features of an imperious paper mulch.

MYCOLOGY

The Smithsonian Institution has deposited with the Bureau of Plant Industry the herbarium of fungi of the late Curtis Gates Lloyd, of Cincinnati, which had been acquired by gift from the trustees. This herbarium is one of the largest in the world and, in fact, is the largest as far as those particular fungus groups in which Mr. Lloyd was interested are concerned. It is particularly rich in those fungi that have economic importance as wood-rotting organisms.

The actual number of specimens is between 50,000 and 100,000. In addition, there are included in the collection about 10,000 negatives of fungus subjects, hundreds of photographic prints, half tones of all the illustrations which appeared in Mr. Lloyd's publications, his many notebooks, his correspond-

ence of a lifetime with the world's mycologists, and a mass of other manuscript records relating not only to his collection but to fungi in general. The collection is now being catalogued and arranged for use. It will be maintained as a separate unit, to be known as the C. G. Lloyd Mycological Collection.

Dr. J. R. Weir at the time of severing his connection with the Bureau of Plant Industry donated to the bureau his private herbarium of fungi consisting of more than 20,000 specimens. This herbarium had been gathered by him as a result of effort covering more than 20 years, both through personal collections and by exchange with mycologists in all parts of the world. Special attention had been given to collecting wood-destroying species of the Polyporaceae and related fungus families on as wide a range of hosts as possible, which adds greatly to the economic importance of the collection.

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EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., September 1, 1928.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1928, covering the work done in connection with the construction of Federal-aid, national-forest, and national-park roads, the economic and physical researches in connection with problems of highway improvement, and the research and other work of the division of agricultural engineering.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

Hon W. M. JARDINE,
Secretary of Agriculture.

During the fiscal year 1928 improvements were completed on 8,184 miles of Federal-aid road which had not previously been improved with Federal assistance. Advanced stages of improvement were completed during the year on 2,014 miles. At the close of the year initial improvements were in progress on 9,494 miles and advanced or stage construction was under way on 1,285 miles.

All of this work was or is being done on roads which are parts of the Federal-aid highway system, consisting of 187,753 miles of main interstate and intercounty highways.

The total mileage initially improved with Federal aid since the beginning of the Federal cooperation is 72,394 miles. As the original length of these roads has been shortened by subsequent relocations by a total of 34.4 miles throughout the entire period, and as there is a portion of the total amounting to 1,285 miles which is now undergoing stage construction, the mileage classified as completed at the close of this fiscal year is 71,074 miles.

By the completion of 281 miles during the fiscal year the mileage of completed roads built in cooperation with the Forest Service under the bureau's

supervision in the national forests is brought to 3,775 miles. Of this total, 3,484 miles are in 12 Western States and the Territory of Alaska and 291 miles are in 11 Eastern States. These improved roads are portions of the forest-road system which has been designated jointly by State and Federal authorities and which embraces at present a total of 13,911 miles, of which 11,768 miles are in the above-mentioned 12 Western States and Alaska.

Continuing the cooperation with the National Park Service of the Department of the Interior, the bureau has surveyed, planned, and supervised the construction of important roads in the park areas. Working in accordance with a program that calls for the improvement of over 1,500 miles, the result to date is 120 miles built, 164 miles under construction, and an additional 322 miles of survey in progress.

The bureau's connection with the Federal aid, national forest, and national park road work places it in a position where it is able to serve as a correlating agency to give common direction to these three major road activities of the Federal Government. Its exercise of this function is especially needed in the Western States in

which the reserved national areas are largest and most numerous. In these States the intermeshing of the roads in the forests, parks, Indian reservations, and other national areas with the roads of the States outside the borders of the national lands is essential to the development of an adequate highway system. The bureau has accepted the responsibility for accomplishing this result, and the articulation of the Federal aid, national forest, and national park road systems, which constitute the definite programs of future endeavor in the three major classes of road work of interest to the Federal Government, testifies to the success of its efforts. The similar exercise of its coordinating influence in the construction of the roads of all three is bearing fruit which is recognizable in the higher and more uniform standards that now prevail throughout all States and in the development of all highway systems. These very satisfactory results have been achieved through the mutual cooperation of Government bureaus and the pooling of Federal and State effort, and it is gratifying to be able to report them in view of the present widespread interest in rational governmental coordination.

The application of similar methods of intermediation and coordination is largely responsible for the significant success which has attended the bureau's most important economic research project of the year—the planning of a highway system which will relieve traffic congestion in the metropolitan region about the city of Cleveland, Ohio. In the area affected by highway traffic originating in and destined to Cleveland there are parts of seven counties. In Cuyahoga County alone there are 4 cities, 49 incorporated villages, and 6 townships, a total of 59 more or less independent jurisdictions, each possessed of authority over the highways within their borders. Faced by a common problem—the provision of adequate arteries for the flow of the increasing traffic of a great metropolitan area—the authorities of the several jurisdictions had been unable to agree upon a concerted plan, and their independent and frequently conflicting efforts had failed to produce a satisfactory solution.

At the request of the board of county commissioners of Cuyahoga County, the bureau agreed to undertake a survey of the highway traffic of the area and on the basis of fact thereby developed to plan a consistent program of improvements designed to relieve the

congestion that had arisen, on one condition, namely, that the authorities of each of the jurisdictions involved would agree to carry out the plan presented and adopted. The condition was accepted, the survey has been made, and a plan of improvement has been drawn up which has met with the enthusiastic indorsement of all authorities. As the fiscal year closes, work is already under way to put into effect some of the more important recommendations, which, if carried out, will doubtless strike at the root of the traffic troubles of the area.

In the department of physical research the study of the characteristics of road-surfacing materials and sub-grade soils and the measurement of the natural and vehicular forces to which the roads are subjected have been carried on with all possible vigor. The problems involved are exceedingly complicated and the necessary duration of the studies correspondingly long. The variables are being attacked one by one; and each year adds to the fund of knowledge which is gradually evolving rational bases of highway design, and which ultimately may be expected to eliminate doubt, to the extent that it is ever possible to do so in works subjected to natural forces, as a factor in the work of highway improvement.

Of far-reaching importance are the investigations which have for their purpose the development of types of road surface low in cost and yet capable of bearing the year round, without dust in summer and mud in winter, the light traffic which must be accommodated by hundreds of thousands of miles of local roads. The investigations in this field, conducted by the bureau in cooperation with the highway departments of California and South Carolina, have had results of great promise and utility.

The treatment of fine crushed gravel and rock roads with asphaltic fuel oils, by methods modified and improved as a result of the cooperative investigation with California, has been especially effective in the arid and semi-arid Western States where, on untreated stone roads, the dust nuisance had become intolerable. Already 2,500 miles of crushed-stone roads have been treated by this method in 9 Western States, and when the season's current program is completed there will be over 3,000 miles in 11 States. The treatment strikingly improves the riding qualities of the roads, completely eliminates dust, and reduces surface

wear to a negligible quantity at a cost which, under efficient management, does not exceed \$1,700 a mile.

In the South Carolina investigations the aim is to develop a similar treatment which will be applicable to various earth and stone surfaces and which will produce satisfactory results in the more humid sections of the country.

The test of the concrete-arch bridge over the Pee Dee River near Albemarle, N. C., of which mention was made in the report for the preceding fiscal year, has been completed, and the analysis of the data obtained is nearing completion. This test, which was conducted cooperatively by the bureau and the North Carolina State Highway Commission, has commanded the interest of bridge engineers throughout the world.

The importance of the test is due to the fact that it offers an unparalleled opportunity to verify the accuracy of the accepted design theory by a comparison of theoretical stresses with those actually produced by test loads. The results will have great scientific value and it is expected that they will point the way to a more accurate and economical proportioning of structures of this type.

The efforts to promote efficiency and economy in road construction operations, begun several years ago, have dealt this year particularly with three questions: (1) The possibilities of economy in the operation of power shovels used in grading; (2) the effect of the length of mixing time on the strength of concrete mixed in standard highway paving mixers, and the possibility of effecting economies by reducing the length of the mixing period, and (3) the possibility of producing asphaltic and bituminous concrete surfaces of greater smoothness and lower cost by the use of mechanical finishing methods.

The first two lines of study have been carried to the point of establishing with considerable conviction just what economies may be effected without detracting from the service qualities of the roads. The latter, which was begun coincidentally with the first experimental uses of finishing machines on bituminous surfaces, has been an invaluable guide in the perfection of the machines and methods of operation, and is being continued with a view to promoting still further efficiency in this most recent application of mechanical power to road construction.

Seeing what is believed to be a serious menace to the free flow of highway traffic in the extraordinary activity of promoters of private toll bridges on important State and interstate arteries, the bureau undertook an investigation of the situation, which was completed during the past year. The investigation disclosed the number and location of toll bridges already in operation and under construction and showed that a majority are on the Federal-aid highway system. It directed public attention to the alarming increase in the number of applications for legislation permitting the erection of such bridges; and pointed out the alternative means that might be adopted to provide needed bridges by public initiative and thus prevent the private exploitation of highway facilities built so largely at public expense. In fairly and wisely meeting this situation the administrative authorities of the States and Federal Government need legislative support which it is confidently expected will not be denied.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

In the Federal-aid highway system, designated as required by the act of November 9, 1921, there are at present 187,753 miles of main interstate and intercounty highways. All Federal funds appropriated since the passage of the act have been applied to the improvement of this limited system. As a result of this wise policy continuously followed for eight years the major highway system of the Nation has been steadily improved, and the independent efforts of the States applied to the same system have furthered the results of the cooperative undertakings; so that initial improvements have now been made on more than three-fourths of the entire mileage.

The cooperation with the States has this year added the initial improvement of 8,184 miles, increasing the total mileage upon which improvements have been completed from the 64,210 miles of a year ago to 72,394 miles. The latter figure represents the total mileage initially improved since the inception of the Federal-aid policy in 1916. With the exception of a small amount of work done before the passage of the act of 1921, all of this mileage is included in the Federal-aid system.

By relocations made in the course of subsequent construction this initially improved mileage has been reduced by

approximately 34 miles, and there are at present 1,285 miles which, because they are now undergoing further stages of improvement are temporarily transferred from the classification of improved mileage. With these deductions the total mileage classified as improved stands at 71,074 miles.

A year ago the mileage reported as initially improved was 64,210 miles. This included 1,213 miles which were then undergoing stage construction and nearly 23 miles, the aggregate shortening of the routes resulting from advanced improvements up to that time. With these deducted the total classified as improved was 63,974 miles. Comparing this figure with the 71,074 miles now classified as improved, after taking account of reductions in the length of routes and sections of previously improved road now undergoing further improvement, it will be seen that the increase in the improved mileage classification is 8,100 miles.

Exact figures representing the mileage in the system improved by the States without Federal assistance are still unavailable; but reliable estimates by State highway officials indicate that the total exceeds the mileage improved with Federal aid; and it is probable that the aggregate length of all sections initially improved to date is not far from 150,000 miles.

ADVANCED IMPROVEMENTS MULTIPLY

While initial improvement has thus been extended to a very large portion of the designated system, advanced or so-called stage construction has been carried on on sections of road already initially improved where traffic growth has demanded and available funds and sound public policy have permitted.

As the minimum traffic requirements are met by the extension of initial improvement to a constantly increasing mileage it becomes possible to direct the available resources of money, man, and materials in increasing measure to the further betterment of the initially graded or lightly surfaced roads and to refinements of grade, location, and design which were deliberately omitted in the first stage of improvement in order to make limited resources go as far as possible.

Such further improvements were completed during the past year on 2,014 miles of highways previously improved with Federal aid. This work does not increase the total of mileage improved. In fact, it generally has the effect of slightly decreasing the

mileage of improved road in the system by the amount of the shortening in distance which results from relocations found to be possible and desirable.

During the past year the mileage of improved road in the Federal-aid system was decreased by such relocations and other revisions by a total of about 11 miles, which, added to similar reductions previously effected and totaling approximately 23 miles, brings the total shortening of distance to about 34 miles.

But, although the stage-construction work does not add to the total of mileage improved, it does add to the work accomplished; and the mileage dealt with this year amounts to nearly a fourth of the mileage initially improved. If the mileage on which stage construction was completed during the year is added to the mileage initially improved in the same period, the total mileage upon which work has been completed during the year is found to be 10,198 miles. As the corresponding figure for the preceding year was 9,683 miles, it is apparent that the work done during the past year considerably exceeded the accomplishment of the preceding year.

The tendency to devote greater attention to stage construction as the initial improvement of the system nears completion is indicated by the fact that, whereas the mileage thus further improved during the fiscal year 1927 was about 16 per cent of the mileage of initial improvement completed, the corresponding ratio for the past year's work was nearly 25 per cent. It is further illustrated by the fact that the mileage of stage construction completed during the past year exceeded by over 600 miles the completed mileage of similar construction in the preceding year, which far exceeded the similar work done in previous years.

The subsequent improvements invariably enhance the service value of the highways. They consist generally of the application of a surface to a previously graded road or the substitution of an improved surface for a previously placed surface of lower type. In some cases the improvement involves relocation of the highway as originally built, to rectify alignment, eliminate grade crossings of railroads, or for other purposes.

Considered in the aggregate, the effect of the stage construction is to raise gradually the standard of improvement upon the system as a whole and this, despite the fact that the progress of

initial improvement is adding to the completed mileage each year a large mileage of graded and drained roads and roads temporarily surfaced with low-grade material. Thus, in the past year initial improvement added to the improved mileage 2,182 miles of graded and drained earth roads without surfacing of any sort. But in the same period, previously built earth roads were surfaced by stage construction so that the net increase in the mileage of unsurfaced roads was only 685 miles. And, whereas the high-type pavements of brick, concrete, and bituminous concrete, completed as initial improvements during the year was 2,711 miles, the net increase in mileage of these high types was 3,336 miles, the differential being the contribution of stage construction.

Slowly but surely the general level of improvement of the system is being raised in this way even while the pioneering effort still adds largely each year to the mileage improved by low types. Whereas graded and drained earth roads two years ago made up more than 17 per cent of the entire improved mileage, they now constitute only 15 per cent. Where two years ago the mileage of pavements completed was less than 26 per cent of the total completed mileage, to-day it approaches 29 per cent.

TYPES OF FEDERAL-AID ROADS

The 8,184 miles of initial improvement completed during the year include 2,182 miles of graded and drained earth roads, 844 miles of sand-clay roads, 1,836 miles of gravel roads, 92 miles of water-bound macadam roads, 464 miles of bituminous macadam roads, 136 miles of bituminous concrete pavement, 2,533 miles of Portland cement concrete pavement, and 42 miles paved with vitrified brick. The remaining 54 miles were made up of numerous bridges and their approaches, each structure being more than 20 feet in length.

Determination of the surface type of the roads built, responsibility for which is shared by the Federal and State authorities, rests primarily upon the needs of the traffic carried by each individual section of road. This primary consideration is modified to a degree by the desirability of extending some measure of improvement as rapidly as possible to the entire highway system.

Notably in the States of the South and West, by reason of their large

size, their comparative sparsity of population and limited public revenues, and the less advanced stage which characterizes the development of their highway systems, these further considerations appeal with much force. Consequently it will be found that in these States the initial improvements include, in greater proportion than in the Eastern and Northern States, the lower types of surfaces. That such considerations have not induced the construction of types of surfaces clearly out of accord with the demands of traffic is indicated by Table 1, which presents an analysis of the proportions of low and high types of surface construction in the several geographic regions in relation to the general density of motor-vehicle traffic, as roughly expressed by the number of registered motor vehicles per mile of the Federal-aid highway system in each region.

TABLE 1.—*Relation of the types of initial improvements completed during the fiscal year 1928 and the general density of motor-vehicle traffic on the Federal-aid highway system by groups of States*

Group of States	Number of motor vehicles per mile of Federal-aid system ¹	Percentage of mileage of initial improvements completed	
		Bituminous macadam and higher types	Water-bound macadam and lower types
Middle Atlantic....	362	91.4	8.6
New England.....	241	78.3	21.7
Pacific.....	219	44.5	55.5
East North Central..	203	75.2	24.8
South Atlantic.....	102	62.1	37.9
West South Central..	83	36.1	63.9
East South Central..	72	21.0	79.0
West North Central..	67	16.4	83.6
Mountain.....	36	2.4	97.6
All States.....	123	38.8	61.2

¹ As registered in the several States during the calendar year 1927.

As would naturally be expected from the foregoing statements, Table 2 shows that the mileage of stage construction or advanced improvements completed is greatest in the West and South and least in the wealthy, populous, advanced, and territorially limited States of the Middle Atlantic and New England groups.

TABLE 2.—*Mileage of stage construction completed during the fiscal year 1928, by groups of States*

Group of States	Mileage of stage construction completed during the year	Percentage of the total
New England.....	0.0	0.0
Middle Atlantic.....	3.0	.1
South Atlantic.....	186.8	9.2
East North Central.....	40.3	2.0
East South Central.....	96.0	4.8
West North Central.....	1,214.8	60.3
West South Central.....	286.5	14.3
Mountain.....	148.2	7.4
Pacific.....	38.6	1.9
All States.....	2,014.2	100.0

Roads included in the Federal-aid system are by and large the most heavily traveled in the United States. They are the main interstate and inter-county roads and are included in the designated mileage for this reason. In the States in which traffic surveys have been made by the bureau it has been possible to measure the relative traffic importance of the Federal-aid roads and other roads of the States, and these determinations have shown invariably the greater utilization of the Federal-aid system.

In Vermont the average traffic on all roads of the Federal-aid system was found to be 702 vehicles per day. The traffic on all other numbered State routes (the most important State roads outside the Federal system) averaged 293 vehicles per day.

In New Hampshire the observed traffic on the Federal-aid roads averaged 1,088 vehicles per day; on other State trunk lines it averaged 551 vehicles per day.

In Ohio the Federal-aid roads carried in 1925 an average of 708 vehicles a day, and other roads of the State highway system showed a daily traffic average of 538.

The Connecticut survey in 1923 indicated an average traffic utilization of the Federal-aid system exceeding by 15 per cent the average for the entire State system.

The types of road surface that have been found by experience and test to be especially suitable for dense and heavy traffic are bituminous macadam and the several pavement types. This being true, the mileage improved with Federal aid should show a greater percentage of these higher types of surface than other improved State roads.

That this condition actually exists is indicated by the analysis presented in Table 3, where the surface types of completed Federal-aid roads are compared with those of all other State-built roads. Table 3 is merely indicative of the superiority of improvements on the Federal-aid system. A considerable part of the mileage built by the States without Federal aid is also on the Federal-aid system. If it were possible to separate this mileage from that not included in the system it would doubtless show a type classification similar to that of the roads built with Federal aid, and the percentage of the higher types on the remaining portion of the State systems would probably be lower than the percentage shown by Table 3 for all unaided construction.

TABLE 3.—*Percentages of high and low types of surfaces on Federal-aid roads completed to June 30, 1928, and State roads built without Federal aid to December 31, 1927*

System	Water-bound macadam and lower types, percentage of total	Bituminous macadam and higher types, percentage of total
Federal-aid roads.....	65.2	34.8
State roads (exclusive of roads built with Federal aid).....	173.9	126.1

¹ These percentages are obtained by subtraction of the mileage of Federal-aid roads completed to June 30, 1928, from the mileage of all State roads completed to Dec. 31, 1927. The interval of six months and the fact that a small mileage of Federal-aid roads is not included in the State systems have no material effect upon the percentages.

The response to the increasing demands of a growing traffic is shown by the greater increase in the types more suitable for heavy traffic. With regard to the Federal-aid roads this fact is evidenced by Table 4, which shows that the net result of the last-year's work was to increase the mileage of completed high types of road by 19.3 per cent, while the mileage of completed low types increased but 9.7 per cent.

Combining to produce this result there are the two policies of opposite tendency: on the one hand the policy of extending pioneer improved mileage as rapidly as possible by construction of low type, and on the other the upbuilding policy of stage construction. The effect of the latter policy is indicated by the fact that although the year's

initial construction added to the completed mileage 2,182 miles of unsurfaced earth roads and 2,553 miles of concrete pavement, the net increase in the completed mileage of earth road was only 685 miles, while the net increase in the mileage of concrete pavement was 3,131 miles.

TABLE 4.—*Mileage of the several types of Federal-aid roads improved at the close of the fiscal years 1927 and 1928 and percentage of increase*

Type	Mileage at close of fiscal year 1927 ¹	Mileage at close of fiscal year 1928 ¹	Percentage increase during fiscal year 1928
Graded and drained	9,926.6	10,611.3	6.9
Sand-clay	5,578.9	6,470.9	16.1
Gravel	25,337.7	27,698.3	9.3
Water-bound macadam	1,300.1	1,426.6	9.7
Bituminous macadam	3,670.0	4,317.2	17.6
Bituminous concrete	1,834.3	1,993.3	8.7
Portland cement concrete	14,385.7	17,516.3	21.8
Brick	771.8	817.9	6.0
Total	62,805.1	70,851.8	12.8

¹ Mileage under stage construction at the close of the year and reductions in mileage by relocation, etc., deducted from total mileage completed.

The 2,182 miles initially improved by grading and draining and the additional mileage initially improved with low-type surfaces constitute a very considerable betterment of the preexisting conditions. These initial improvements will serve present traffic with at least a fair degree of satisfaction, and the service will be improved by stage construction if and when it is required within the limit of funds available. If in the initial improvement the several types had been represented in the same proportions as their net increases during the

year, a certain mileage, possibly as much as a thousand miles, that has been improved to a measurable degree would still be wholly unimproved.

FEDERAL-AID BRIDGE CONSTRUCTION

The Federal-aid bridges completed during the year, with their approaches, have an aggregate length of over 54 miles. In the preceding year the aggregate length of the structures completed was not quite 46 miles, and this was more than twice the mileage completed during the fiscal year 1926. The year's results in bridge construction, as will be seen from these comparisons, are worthy of special note.

The bridges under construction and approved for construction at the close of the year have, with their approaches, an aggregate length of nearly 68 miles, exceeding by more than 3 miles the total length of structures in the corresponding stages of progress at the beginning of the year.

Including the structures just completed, the Federal-aid bridges now standing have a total length, with their approaches, of 222.5 miles, nearly a fourth of which was added during the last year.

All of these structures are more than 20 feet in clear span, and in several instances the structures with their necessary approaches span distances of a mile and more.

A list of the bridges completed during the year which cost \$75,000 or more is given in Table 5. These, the longest and most expensive of the projects completed, vary in length from about a tenth of a mile to a mile and more, and have an aggregate length of 29.6 miles. The remainder of the mileage completed is made up of numerous smaller and less expensive bridges. The total number of bridges of all lengths from 20 feet upward completed during the year for which the final Federal payment has been made is 1,544.

TABLE 5.—Federal-aid bridges completed during the fiscal year 1928 at a cost of \$75,000 or more each

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				Miles
Arizona.....	Between Phoenix and Yuma.....	Gila River.....	\$317,400	0.3
California.....	Between Redding and Yreka.....	Dog Creek.....	119,600	.1
Do.....	Between Los Angeles and Whittier.....	Rio Hondo River.....	91,600	
Do.....	Between Santa Barbara and San Luis Obispo.....	Santa Maria River.....	110,400	.4
Do.....	Between Los Angeles and Santa Ana.....	Santa Ana River.....	98,800	.1
Do.....	Between American River and Sacramento County line.....	Underpass, Southern Pacific R. R.....	77,500	.3
Colorado.....	Between Craig and Meeker.....	Yampa River.....	89,500	.9
Connecticut.....	At Gaylordsville.....	Housatonic River.....	111,800	.2
Do.....	Between Norwich and Putnam.....	Overhead bridges and approaches over N. Y., N. H. & H. R. R.....	87,900	.2
Do.....	Between Hartford and Meriden.....		160,900	.8
Do.....	Between Hartford and Massachusetts State line.....		124,500	.7
Florida.....	Between Pensacola and Milton.....	Escambia Bay and River.....	983,400	3.5
Do.....	Between Brevard and St. Lucie Counties.....	Sebastian River.....	226,800	.4
Georgia.....	Between Bainbridge and Brinson.....	Flint River.....	326,200	.4
Do.....	Between Abbeville, Ala., and Fort Gaines, Ga.....	Chattahoochee River.....	169,900	.6
Do.....	Between Brunswick and Florida State line.....	Satilla River.....	113,600	.1
Do.....	Between Lyons and Baxley.....	Altamaha River.....	202,000	.1
Do.....	Between Elbert County, Ga., and Abbeville County, S. C.....	Savannah River.....	227,200	.3
Idaho.....	Between Sand Point and Washington State line.....	Clark's Fork.....	209,000	.5
Kansas.....	Between Oklahoma State line and Winfield.....	Arkansas River.....	84,700	.1
Kentucky.....	Between Prestonburg and Paintsville.....	Levisa Fork of Big Sandy River.....	106,400	.1
Louisiana.....	Between Pearl River, La., and Logtown, Miss.....	West Pearl River.....	132,200	.1
Do.....	Between Vinton and Sabine River bridge.....	Eastern approach of Sabine River bridge.....	520,200	2.9
Do.....	Between Houma and Morgan City.....	Bayou Boeuf.....	151,600	.1
Michigan.....	Between Monroe and Tecumseh.....	Underpass, Detroit, Toledo & Ironton R. R.....	126,600	.3
Do.....	Between Hudson and Farmington.....	Overhead crossing, Pere Marquette R. R.....	156,700	.1
Do.....	Between Plymouth and Detroit.....	Underpass, Pere Marquette R. R.....	157,800	
Do.....	Between Flat Rock and Dearborn.....	Underpass, Detroit, Toledo & Ironton R. R.....	222,500	.3
Mississippi.....	Between Gulfport and Bay St. Louis.....	Bay St. Louis.....	813,800	2.0
Do.....	At Columbus.....	Tombigbee River.....	156,900	.1
Missouri.....	At Fenton.....	Meramec River.....	108,100	.1
Montana.....	Between Polson and Kalispell.....	Flathead River.....	99,900	.4
Do.....	Between Laurel and Billings.....	Underpass, Northern Pacific Ry.....	80,000	.4
Do.....	Between St. Regis and Missoula.....	Clark's Fork of Columbia River.....	85,600	.1
New Mexico.....	Between Fort Sumner and Vaughn.....	Pecos River.....	123,300	.2
New York.....	Between Binghamton and Oneonta.....	Overhead crossing, New York, Ontario & Western Ry.....	83,400	.5
North Carolina.....	Between Morehead City and Beaufort.....	Newport River (two bridges).....	528,500	.6
North Dakota.....	Between Schafer and Sanish.....	Missouri River.....	436,600	.2
Do.....	Between Alexander and Williston.....	Missouri River.....	584,700	.3
Ohio.....	Corporation line at the city of Piqua.....	Overhead crossing, Baltimore & Ohio R. R.....	128,600	.1
Oklahoma.....	Between Weleetka and Wetumka.....	North Canadian River.....	83,700	
Do.....	Between Pawnee and Ponca City.....	Arkansas River.....	256,100	.4
Oregon.....	Between Newport and Hebo.....	Siletz River.....	113,100	.1
South Carolina.....	Between Charleston and St. Andrews Parish.....	Ashley River.....	1,122,000	.3
Do.....	Between Conway and Georgetown.....	Pee Dee River.....	396,700	1.7
Do.....	Between Manning and St. George.....	Santee River.....	432,100	1.8
Do.....	Between Fort Lawn and Lancaster.....	Catawba River.....	175,300	.8

TABLE 5.—Federal-aid bridges completed during the fiscal year 1928 at a cost of \$75,000 or more each—Continued

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				<i>Miles</i>
Tennessee.....	Between Humbolt and Jackson.....	Middle Fork of the Fork Deer River.	\$83,500	0.2
Do.....	Between Newport and North Carolina line.	French Broad River..	111,900	.3
Texas.....	Between Wichita Falls and Randlett, Okla.	Red River.....	210,700	.1
Do.....	Between Jefferson and Orange Counties at Beaumont.	Neches River.....	359,400	.6
Do.....	Between Orange County and Calcasieu Parish, La.	Sabine River.....	227,700	.2
Do.....	Between Palestine and Buffalo.....	Trinity River (two bridges).	161,700	.1
Vermont.....	At Brattleboro.....	West River.....	127,800	.3
Virginia.....	Between Warsaw and Tappahannock..	Rappahannock River.	403,200	1.0
Washington.....	Easterly city limits of Tacoma.....	Over Puyallup River and the Northern Pacific, Union Pacific, and Chicago, Milwaukee & St. Paul tracks.	693,400	.5
Do.....	Between Ellensburg and Quincy.....	Columbia River.....	668,100	.5
Do.....	Between Everett and Marysville.....	Four bridges over Snohomish River, Union Slough, Steamboat Slough, and Ebey Slough.	1,033,800	.9
West Virginia.....	Between Fairmont and Pruntytown...	West Fork River.....	126,900	.1
Do.....	At Gauley Bridge.....	Gauley River.....	92,000	.1
Do.....	Between West Hamlin and Logan.....	Guyandot River.....	90,000	.6
Wisconsin.....	Between Milwaukee and Pewaukee....	Milwaukee River.....	260,400	.1

In the preceding annual report the hope was expressed that the use of Federal-aid funds in payment of a part of the cost of important bridges would be continued and increased. The fact that the mileage of bridges now under construction and approved for construction is greater than it was a year ago is therefore distinctly gratifying.

The Federal appropriations may very appropriately be used for this purpose; and, so used, they offer an avenue of escape from the dilemma which confronts the highway departments of many of the States. Faced on one side with the need of expensive bridges to span large streams of important arteries, and on the other with a very natural public desire to have the limited current revenues cover as many miles as possible, the State agencies may be pardoned for indecision as to the expediency of spending in a few localities such large sums as the building of large bridges entails.

Taking advantage of this hesitation on the part of the public agencies, private promoters have been busy acquiring exclusive franchises to build bridges at commanding locations on the publicly built highways and, in compensation therefor, to levy toll upon

the annually increasing number of travelers.

An investigation made by this bureau showed that on October 31, 1927, there were in operation, under construction, or proposed, in the United States 424 toll bridges, of which number 217 were on the Federal-aid highway system.

In the first session of the Seventieth Congress bills were introduced to authorize the construction of 122 new toll bridges and 67 were authorized by acts passed and signed by the President.

Practically three quarters of all these bridges in operation or projected are or will be operated by private interests. The bureau has reliable information that such interests have sought by various means to obstruct the construction of free or publicly operated toll bridges at commanding locations. They have sought to enjoin the construction of public bridges in the courts; and they have attempted and in some cases have succeeded in blocking legislation authorizing the construction of public bridges.

With the purpose of discouraging such imposition of tolls upon users of the highways built in part with Federal aid, the Federal law at first prohibited

the expenditure of any part of the appropriations made by Congress for the construction of roads which serve as the immediate approaches to toll bridges.

Recognizing later the occasional desirability of resort to the toll method of financing in the case of bridges built, owned, and operated by the public itself, the Congress, by amendment of the law, specifically authorized the expenditure of Federal appropriations in payment of half the cost of public bridges, the State's portion of which is to be met by toll collections; and Federal funds may also be used in the construction of approaches to such public toll bridges.

By taking advantage of this provision of the amended law a State can write off at once half the cost of much-needed large bridges. The remainder it can finance without incurring a public debt, in the constitutional sense, by issuing revenue bonds on the security of anticipated toll revenues. By adopting this course the amount to be paid by tolls is cut in half, the bridge can be freed in half the time that would otherwise be required for the payment of its cost, and the public can be assured that it is paying no unnecessary amount of profit to private capitalists.

There is an active market for toll-bridge bonds, and the public can sell on terms that are usually more favorable than those available to private builders. The existing public agencies can erect and operate the bridges as efficiently and economically as private builders. Under public auspices there is assurance of open competition by qualified contracting organizations for the construction of the bridge and the further assurance that the contract will be awarded to the lowest responsible bidder, conditions that have been noticeably lacking in much of the private construction upon which the public has been asked to pay dividends in the form of tolls.

In consideration of these and other facts of similar purport, which it has established by study and investigation, the bureau generally opposes the construction of private toll bridges and favors construction under public auspices whether or not it be necessary to resort to tolls as a measure of finance. It has recommended against the granting of authority to private interests in numerous cases, when congressional bills have been submitted for its consideration; but in many cases its recommendation has not been followed.

The facts in its possession were placed before the Congress at the last session; and it is hoped that a careful consideration of these facts will lead that body to extend the legislative support needed and earnestly desired by the highway administrative authorities of the Government and the States in dealing with this difficult problem of major bridge construction.

STANDARD SIGNS AND WAYSIDE PLANTING

By amendment of the law, Federal appropriations may now be expended to aid the States in the erection of the standard numeral markers and direction and danger signs adopted for the United States highway system, on all parts of that system that are also included in the Federal-aid system. This permission extends to nearly the entire mileage of the United States system, and during the past year a number of the States have taken advantage of the proffered aid.

The erection of these signs on the principal transcontinental highways has contributed immeasurably to the convenience and safety of travel. The signs are well designed and easily understood. They have quickly become familiar to the traveling public, and their erection is uniformly indorsed by road users.

The complete effectiveness of these signs erected at public expense for the greater convenience and safety of travelers is hindered in some instances by advertising signboards so placed as to obscure them or withdraw attention from them. In many cases such advertisements contain misleading information, with regard to intermediate distances on the highway and the condition of the road ahead, which is belied in less obtrusive fashion by the public signs. To the extent that they obscure, or contradict, or divert attention from the proper road signs, these signboards are a positive hindrance and menace to the traveling public.

Designedly placed where they will receive the utmost attention, they frequently obscure or mar attractive roadside views and so detract from the pleasurable use of the highways. Accustomed as we are to their unwanted presence in ordinary surroundings, to come upon these blatant commercial appeals high on the face of a majestic cliff, marring a mountainside, or completely obscuring a particularly beautiful vista still awakens a sense of their utter incongruity.

In practically all cases these roadside advertisements merely repeat in the same form appeals that are made quite properly and insistently through other agencies. They are unneeded by the public and of doubtful value to the advertisers. Their disfigurement of the landscape is a national disgrace. It is hoped that means may be found by suitable legislation to effect their complete elimination upon all roads constructed in part with money appropriated by the National Government.

The recent amendment of the Federal highway act which permits payment by the Federal Government of part of the cost of wayside planting is timely. The States of California, Connecticut, and Massachusetts, and others have already demonstrated how much can be done at small cost to beautify the roadsides by judicious planting of native trees, shrubs, and perennial flowers. With the cooperation of forestry and horticultural authorities of the States and Federal Government and the support of civic bodies and property owners similar attractive results can be quickly and cheaply obtained in other States.

The public acquisition of suitable tracts of land at intervals along the highways, and the development of such tracts as State parks for purposes of recreation and the conservation of timber and animal life; where feasible, the acquisition of small, road-bordering strips and plots for development as parkways and parklets; these ideas should appeal not only to those who have at heart the enhancement of the appearance of the roadsides but also to all persons interested in conservation and larger facilities for outdoor recreation.

THE IMPORTANCE OF PLANNING FOR THE FUTURE

The studies of the flow and growth of highway traffic made by the bureau in recent years have emphasized the fundamental importance of careful present consideration of future needs in reestablishing the location and planning the structure of our highways.

Taking the country as a whole, traffic on the roads has doubled in less than five years' time, and in some States it is still increasing at an even more rapid rate.

The design of motor vehicles has been so perfected that speed considerably in excess of former possibilities can be attained without increase of hazard so far as the vehicles themselves are concerned.

The remarkable developments that have recently occurred in the design and use of common-carrier busses are probably no more than the beginning of a much further development that is to occur in this form of conveyance.

Traffic congestion, until recently a serious problem only in the cities, has moved outward and now imposes its time-consuming delays and menace to life and property upon the principal highways in the vicinity of the large metropolitan centers.

These facts must be taken into account in the planning of future Federal-aid improvements. They point especially to the necessity of acquiring rights of way of ample width to allow for future widening or the making of definite provision for future acquisition as needed; to the importance of designing the highways for safe use at higher speeds; to the desirability of considering the improvement of arterial route with the service of the entire route in mind; and, in metropolitan areas, to the urgency of grade-crossing elimination, wider pavements, and the building of relief and by-pass highways.

FEDERAL FUNDS APPORTIONED AND OBLIGATED

For the fiscal year 1928, the Federal-aid appropriation authorized by Congress was \$75,000,000. This sum, less $2\frac{1}{2}$ per cent deducted for Federal administration and highway research, was apportioned among the several States and the Territory of Hawaii on December 31, 1926. The total amount apportioned was \$73,125,000, and the amounts credited to each State are shown in Table 19.

Although the fiscal year for which the funds were authorized did not begin until July 1, 1927, the law provides that agreements for the expenditure of the money on definite projects may be entered into between the State and Federal authorities as soon as the apportionment has been made, and these agreements become binding obligations of the Federal Government.

On June 30, 1927, at the beginning of the fiscal year, the unobligated balance of all funds apportioned including the apportionment for the fiscal year 1928, was \$69,440,955, or nearly \$3,000,000 less than the apportionment for the year.

This balance was available for obligation under agreements negotiated subsequent to the beginning of the fiscal year. On December 1, 1927, the amount available was again increased

by \$73,125,000, the amount apportioned of the funds authorized for the fiscal year 1929. On June 30, 1928, the unobligated balance of all available funds—including those for the fiscal year 1929—was \$53,643,770. In other words, there had already been obligated, before the beginning of the new fiscal year, nearly \$20,000,000 of the \$73,125,000 authorized for that year. This is in accordance with the provision of the law which directs the Secretary of Agriculture to apportion the authorized appropriations six months before the beginning of the fiscal year for which they are authorized and authorizes him to incur obligations thereunder immediately.

It is apparent from the above that the sums obligated during the fiscal years 1927 and 1928 exceeded the sums authorized and apportioned for those years, and reference to Table 6 will show that this condition has existed since the fiscal year 1923.

TABLE 6.—*Federal-aid funds apportioned to the States and obligated by them for the fiscal years 1923 to 1928, inclusive*

Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year
1923.....	\$48,750,000	\$77,461,559
1924.....	63,375,000	89,866,864
1925.....	73,125,000	87,294,396
1926.....	73,125,000	79,608,897
1927.....	73,125,000	77,453,046
1928.....	73,125,000	88,922,185
Total.....	404,625,000	500,606,947
Average.....	67,437,500	83,434,491

For the 6 year period (1923 to 1928, inclusive) the average amount obligated annually was \$83,434,491 (Table 6), and the average sum apportioned was \$67,437,500. At the close of each year of this period the unobligated balance has been smaller than at the close of the previous year, and at present the balance available of all funds thus far apportioned, including those for the ensuing fiscal year (1929), is less by nearly \$20,000,000 than the authorized appropriation for the latter year.

It is apparent from the foregoing analysis that for several years the Federal-aid road program has exceeded the amount of appropriations currently authorized. Prior to the

fiscal year 1927 the excess of obligations over authorizations served to reduce the accumulated unobligated balance of earlier authorizations. In that year the accumulated balance was wiped out, and the accustomed rate of obligation has been maintained only by heavy obligation of funds authorized for the succeeding year in the six months between the date of their apportionment and the beginning of the new fiscal year. Obviously this practice is self-terminating, and it will be necessary eventually either to reduce the annual program or increase the appropriations annually authorized.

COST OF THE ROADS

The total cost of the 8,184 miles of initial construction and the 2,014 miles of stage construction completed during the year was \$205,043,784, of which the Federal Government paid \$88,056,984, or 43 per cent, and the States the balance. These expenditures were made over the period required to construct the roads brought to completion during the year, which was approximately two years. During the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal-aid funds during the year was \$80,802,232 55, as shown in Table 19. This expenditure was about a half million dollars less than the expenditure of the previous year.

The largest disbursements during the year were made to Illinois, Iowa, Kansas, New York, Pennsylvania, and Texas. To each of these States the Federal Government paid during the year more than \$3,000,000. All other States received less than that amount.

SUMMARY OF FEDERAL-AID ROAD WORK, BY STATES

The progress made in each of the States during the year and the results of the 12 years of Federal-aid road construction are set forth in the following condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles, of which 1,748 miles have been improved with Federal aid. Of the improved mileage, 310 miles were added during the year. At the close of the year 270.5 miles were under construction and 48.7 miles were approved.

The mileage improved with Federal aid consists of 65.7 miles of graded and drained earth roads, 524.7 miles of sand-clay, 886.8 miles of gravel, 11.6 miles of water-bound macadam, 74.1 miles of bituminous macadam, 87.5 miles of bituminous concrete, and 91.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5.8 miles.

The total cost of all Federal-aid roads completed during the year, including 1.9 miles of stage construction, was \$4,495,050.49 of which the Federal share was \$2,178,119.49. The disbursement of Federal funds to the State was \$2,759,986.85. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,645,844.81.

ARIZONA

The Federal-aid highway system includes 1,498 miles, of which 851.4 miles have been improved with Federal aid. Of the improved mileage, 16.1 miles were added during the year. At the close of the year 86 miles were under construction.

The mileage improved with Federal aid consists of 124.7 miles of graded and drained earth roads, 115.8 miles of sand-clay, 458.2 miles of gravel, 14.2 miles of water-bound macadam, 26.6 miles of bituminous concrete, and 108.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3 miles.

The total cost of all Federal-aid roads completed during the year was \$655,349.80 of which the Federal share was \$467,215.24. The disbursement of Federal funds to the State was \$422,436.01. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$2,896,024.65.

ARKANSAS

The Federal-aid highway system includes 5,021.1 miles, of which 1,678.2 miles have been improved with Federal aid. Of the improved mileage, 90.7 miles were added during the year. At the close of the year 180.7 miles were under construction and 9.9 miles were approved.

The mileage improved with Federal aid consists of 11.3 miles of graded and drained earth roads, 3 miles of sand-clay, 1,122.3 miles of gravel, 48.3 miles of water-bound macadam, 112.2 miles of bituminous macadam, 256.3 miles of bituminous concrete, and 120.9 miles

of Portland cement concrete, in addition to which there are bridges with a total length of 3.9 miles.

The total cost of all Federal aid roads completed during the year was \$954,845.03, of which the Federal share was \$445,342.40. The disbursement of Federal funds to the State was \$796,612.86. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,766,771.75.

CALIFORNIA

The Federal-aid highway system includes 4,771.5 miles, of which 1,455.6 miles have been improved with Federal aid. Of the improved mileage, 98.5 miles were added during the year. At the close of the year 120.7 miles were under construction and 43.7 miles were approved.

The mileage improved with Federal aid consists of 315.8 miles of graded and drained earth roads, 357 miles of gravel, 18.7 miles of water-bound macadam, 63.7 miles of bituminous macadam 141.6 miles of bituminous concrete, 553 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5.8 miles.

The total cost all Federal-aid roads completed during the year was \$4,395,894.90, of which the Federal share was \$1,771,379.44. The disbursement of Federal funds to the State was \$2,444,944.39. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$3,363,012.39.

COLORADO

The Federal-aid highway system includes 3,332 miles, of which 979.3 miles have been improved with Federal aid. Of the improved mileage, 24.9 miles were added during the year. At the close of the year 189.4 miles were under construction and 12.7 miles were approved.

The mileage improved with Federal aid consists of 226.2 miles of graded and drained earth roads, 96.2 miles of sand-clay, 426.5 miles of gravel, 4 miles of bituminous concrete, and 219.4 miles of Portland cement concrete, in addition to which there are bridges with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 3.2 miles of stage construction, was \$905,351.91 of which the Federal share was \$455,668.30. The disburse-

ment of Federal funds to the State was \$1,371,058.74. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$2,573,202.04.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles, of which 206.5 miles have been improved with Federal aid. Of the improved mileage, 55.5 miles were added during the year. At the close of the year 34.4 miles were under construction and 3.6 miles were approved.

The mileage improved with Federal aid consists of 0.2 mile of gravel, 17.4 miles of water-bound macadam, 27 miles of bituminous macadam, 0.6 mile of bituminous concrete, and 158.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year was \$3,906,025.81 of which the Federal share was \$1,124,080.50. The disbursement of Federal funds to the State was \$415,289.33. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$566,752.61.

DELAWARE

The Federal-aid highway system includes 431.5 miles, of which 195.7 miles have been improved with Federal aid. Of the improved mileage, 35 miles were added during the year. At the close of the year 5.7 miles were under construction and 12.9 miles were approved.

The mileage improved with Federal aid consists of 5 miles of water-bound macadam, 7 miles of bituminous macadam, 13.7 miles of bituminous concrete, 167.2 miles of Portland cement concrete, and 2.3 miles of brick, in addition to which there are bridges with a total length of 0.5 mile.

The total cost of all Federal-aid roads completed during the year was \$808,932.97, of which the Federal share was \$361,314.04. The disbursement of Federal funds to the State was \$396,176.60. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$190,680.44.

FLORIDA

The Federal-aid highway system includes 1,926 miles, of which 385.8 miles have been improved with Federal aid.

Of the improved mileage, 75.6 miles were added during the year. At the close of the year 99.7 miles were under construction and 30.7 miles were approved.

The mileage improved with Federal aid consists of 9 miles of graded and drained earth roads, 15.7 miles of sand-clay, 69.8 miles of gravel, 29.8 miles of water-bound macadam, 78.9 miles of bituminous macadam, 42 miles of bituminous concrete, 123.4 miles of Portland cement concrete, and 10.1 miles of brick, in addition to which there are bridges with a total length of 7.1 miles.

The total cost of all Federal-aid roads completed during the year was \$3,497,582.47, of which the Federal share was \$1,556,930.83. The disbursement of Federal funds to the State was \$1,261,265.91. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,210,489.75.

GEORGIA

The Federal-aid highway system includes 5,576.7 miles, of which 2,457.5 miles have been improved with Federal aid. Of the improved mileage, 118.2 miles were added during the year. At the close of the year 168.2 miles were under construction and 102.3 miles were approved.

The mileage improved with Federal aid consists of 210.5 miles of graded and drained earth roads, 1,173.4 miles of sand-clay, 413.6 miles of gravel, 86.9 miles of water-bound macadam, 134.3 miles of bituminous macadam, 26.8 miles of bituminous concrete, 384.4 miles of Portland cement concrete, and 0.5 mile of brick, in addition to which there are bridges with a total length of 27.1 miles.

The total cost of all Federal-aid roads completed during the year, including 90.9 miles of stage construction, was \$4,816,753.53, of which the Federal share was \$2,227,438.42. The disbursement of Federal funds to the State was \$2,260,205.94. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$17,567.82.

IDAHO

The Federal-aid highway system includes 2,770 miles, of which 937.1 miles have been improved with Federal aid. Of the improved mileage, 43.5 miles were added during the year. At the close of the year 116.5 miles were under

construction and 101.6 miles were approved.

The mileage improved with Federal aid consists of 185.2 miles of graded and drained earth roads, 13.9 miles of sand-clay, 592 miles of gravel, 22.5 miles of water-bound macadam, 49 miles of bituminous macadam, 79.3 miles of bituminous concrete, and 36.3 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3 miles.

The total cost of all Federal-aid roads completed during the year, including 32.2 miles of stage construction, was \$1,187,587.69 of which the Federal share was \$729,934.10. The disbursement of Federal funds to the State was \$936,021.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$138 890.41.

ILLINOIS

The Federal-aid highway system includes 6,618.5 miles, of which 1,685.4 miles have been improved with Federal aid. Of the improved mileage, 142.2 miles were added during the year. At the close of the year 620.1 miles were under construction and 148 miles were approved.

The mileage improved with Federal aid consists of 110.3 miles of graded and drained earth roads, 0.4 mile of gravel, 3.4 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,536 miles of Portland cement concrete, and 25.8 miles of brick, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year was \$3,918,735.90, of which the Federal share was \$1,901,874.76. The disbursement of Federal funds to the State was \$3,021,486.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$114,597.22.

INDIANA

The Federal-aid highway system includes 4,701.5 miles, of which 1,060.1 miles have been improved with Federal aid. Of the improved mileage, 222.1 miles were added during the year. At the close of the year 314.2 miles were under construction and 61.3 miles were approved.

The mileage improved with Federal aid consists of 13.5 miles of graded and drained earth roads, 42.2 miles of gravel, 41.6 miles of water-bound macadam, 23.4 miles of bituminous

macadam, 12 miles of bituminous concrete, 917.2 miles of Portland cement concrete, and 6.6 miles of brick, in addition to which there are bridges with a total length of 3.6 miles.

The total cost of all Federal-aid roads completed during the year, was \$6,007,355.89 of which the Federal share was \$2,915,222.26. The disbursement of Federal funds to the State was \$2,767,823.43. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$267,083.14.

IOWA

The Federal-aid highway system includes 7,212 miles, of which 2,831.5 miles have been improved with Federal aid. Of the improved mileage, 378.8 miles were added during the year. At the close of the year 145.2 miles were under construction and 10.2 miles were approved.

The mileage improved with Federal aid consists of 1,455.6 miles of graded and drained earth roads, 566.2 miles of gravel, 786 miles of Portland cement concrete, and 22 miles of brick, in addition to which there are bridges with a total length of 1.7 miles.

The total cost of all Federal-aid roads completed during the year, including 84.7 miles of stage construction, was \$8,915,667.75, of which the Federal share was \$4,115,257.62. The disbursement of Federal funds to the State was \$3,507,729.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$171,307.77.

KANSAS

The Federal-aid highway system includes 7,925 miles, of which 2,202.4 miles have been improved with Federal aid. Of the improved mileage, 578.3 miles were added during the year. At the close of the year 242.8 miles were under construction and 106.3 miles were approved.

The mileage improved with Federal aid consists of 877.3 miles of graded and drained earth roads, 217.1 miles of sand-clay, 229.8 miles of gravel, 4.5 miles of water-bound macadam, 113.9 miles of bituminous macadam, 3.5 miles of bituminous concrete, 590 miles of Portland cement concrete, and 153.9 miles of brick, in addition to which there are bridges with a total length of 12.4 miles.

The total cost of all Federal-aid roads completed during the year, in-

cluding 18 miles of stage construction, was \$9,592,174.56, of which the Federal share was \$4,023,845.38. The disbursement of Federal funds to the State was \$3,071,637.66. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,284,552.84.

KENTUCKY

The Federal-aid highway system includes 3,702.5 miles, of which 1,148.9 miles have been improved with Federal aid. Of the improved mileage, 250.9 miles were added during the year. At the close of the year 227.4 miles were under construction and 62.7 miles were approved.

The mileage improved with Federal aid consists of 522 miles of graded and drained earth roads, 246.1 miles of gravel, 41.3 miles of water-bound macadam, 182.2 miles of bituminous macadam, 1 mile of bituminous concrete, 150.2 miles of Portland cement concrete, and 3.9 miles of brick, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year, including 30.7 miles of stage construction, was \$5,421,784.29, of which the Federal share was \$2,361,246.84. The disbursement of Federal funds to the State was \$2,214,946.66. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$529,296.09.

LOUISIANA

The Federal-aid highway system includes 2,712.9 miles, of which 1,276 miles have been improved with Federal aid. Of the improved mileage, 61.5 miles were added during the year. At the close of the year 193 miles were under construction and 8.8 miles were approved.

The mileage improved with Federal aid consists of 25.6 miles of graded and drained earth roads, 1,173.3 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 33.5 miles of bituminous concrete, and 22.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 8.1 miles.

The total cost of all Federal-aid roads completed during the year, including 7.5 miles of stage construction, was \$2,647,414.58, of which the Federal share was \$1,086,023.19. The disbursement of Federal funds to the

State was \$959,664.41. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$317,573.20.

MAINE

The Federal-aid highway system includes 1,428.9 miles, of which 428.7 miles have been improved with Federal aid. Of the improved mileage, 65.8 miles were added during the year. At the close of the year 39.7 miles were under construction and 14.2 miles were approved.

The mileage improved with Federal aid consists of 192 miles of gravel, 157.2 miles of bituminous macadam, and 79.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.4 mile.

The total cost of all Federal-aid roads completed during the year was \$2,319,089.55, of which the Federal share was \$808,501.50. The disbursement of Federal funds to the State was \$469,884.26. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,380,996.50.

MARYLAND

The Federal-aid highway system includes 1,527.7 miles, of which 557.5 miles have been improved with Federal aid. Of the improved mileage, 75.6 miles were added during the year. At the close of the year 30 miles were under construction and 38.6 miles were approved.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 0.2 mile of water-bound macadam, 200.1 miles of bituminous macadam, 17 miles of bituminous concrete, and 304 miles of Portland cement concrete.

The total cost of all Federal-aid roads completed during the year was \$1,481,188.35, of which the Federal share was \$696,177.50. The disbursement of Federal funds to the State was \$555,946.88. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$143,816.23.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles, of which 501.1 miles have been improved with Federal aid. Of the improved mileage, 60.5 miles

were added during the year. At the close of the year 71.4 miles were under construction and 5.6 miles were approved.

The mileage improved with Federal aid consists of 0.4 mile of gravel, 3.5 miles of water-bound macadam, 259.2 miles of bituminous macadam, 50.5 miles of bituminous concrete, and 183.1 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.4 miles.

The total cost of all Federal-aid roads completed during the year was \$2,957,259.58, of which the Federal share was \$957,873.69. The disbursement of Federal funds to the State was \$676,811.29. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$2,151,418.10.

MICHIGAN

The Federal-aid highway system includes 5,243 miles, of which 1,337.3 miles have been improved with Federal aid. Of the improved mileage, 175.8 miles were added during the year. At the close of the year 328.5 miles were under construction and 29.4 miles were approved.

The mileage improved with Federal aid consists of 10.4 miles of graded and drained earth roads, 364.5 miles of gravel, 18.9 miles of water-bound macadam, 10.4 miles of bituminous macadam, 73.4 miles of bituminous concrete, 857.7 miles of Portland cement concrete, and 0.4 mile of brick, in addition to which there are bridges with a total length of 1.6 miles.

The total cost of all Federal-aid roads completed during the year was \$5,431,692.50, of which the Federal share was \$2,369,018.36. The disbursement of Federal funds to the State was \$2,326,490.95. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$627,344.95.

MINNESOTA

The Federal-aid highway system includes 6,849.6 miles, of which 3,823.8 miles have been improved with Federal aid. Of the improved mileage, 248.7 miles were added during the year. At the close of the year 305.9 miles were under construction and 49.8 miles were approved.

The mileage improved with Federal aid consists of 656.4 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,522.3 miles of gravel, 32.7

miles of bituminous concrete, and 605.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.7 mile.

The total cost of all Federal-aid roads completed during the year, including 110.3 miles of stage construction, was \$5,852,424.86 of which the Federal share was \$2,001,398.90. The disbursement of Federal funds to the State was \$1,986,635.11. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$398,471.43

MISSISSIPPI

The Federal-aid highway system includes 3,604 miles, of which 1,533.6 miles have been improved with Federal aid. Of the improved mileage 187.8 miles were added during the year. At the close of the year 228.3 miles were under construction and 11.5 miles were approved.

The mileage improved with Federal aid consists of 212.4 miles of graded and drained earth roads, 16.6 miles of sand-clay, 1,081.5 miles of gravel, 11.1 miles of water-bound macadam, 1 mile of bituminous macadam, 9.5 miles of bituminous concrete, 186.1 miles of Portland cement concrete, and 9.7 miles of brick, in addition to which there are bridges with a total length of 5.7 miles.

The total cost of all Federal-aid roads completed during the year, including 36 miles of stage construction, was \$4,633,642, of which the Federal share was \$2,246,390.87. The disbursement of Federal funds to the State was \$1,839,908.75. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$892,222.08.

MISSOURI

The Federal-aid highway system includes 7,530 miles, of which 2,210.1 miles have been improved with Federal aid. Of the improved mileage, 171.7 miles were added during the year. At the close of the year 132.8 miles were under construction and 46.3 miles were approved.

The mileage improved with Federal aid consists of 375.3 miles of graded and drained earth roads, 844.7 miles of gravel, 7.4 miles of water-bound macadam, 50.8 miles of bituminous macadam, 17.7 miles of bituminous concrete, 884.1 miles of Portland cement concrete, and 20.9 miles of brick, in addition to which there are bridges with a total length of 9.2 miles.

The total cost of all Federal-aid roads completed during the year, including 22.1 miles of stage construction, was \$4,004,271.51, of which the Federal share was \$2,099,546.14. The disbursement of Federal funds to the State was \$2,658,532.48. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,550,939.55.

MONTANA

The Federal-aid highway system includes 4,673.5 miles, of which 1,299.3 miles have been improved with Federal aid. Of the improved mileage, 142.1 miles were added during the year. At the close of the year 275.6 miles were under construction and 235.1 miles were approved.

The mileage improved with Federal aid consists of 219.5 miles of graded and drained earth roads, 5.6 miles of sand-clay, 1,011 miles of gravel, 17.8 miles of water-bound macadam, 6.9 miles of bituminous macadam, 2.8 miles of bituminous concrete, and 31.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.8 miles.

The total cost of all Federal-aid roads completed during the year, including 9.2 miles of stage construction, was \$1,734,065.14, of which the Federal share was \$1,133,573.73. The disbursement of Federal funds to the State was \$1,778,896.60. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$4,353,988.31.

NEBRASKA

The Federal-aid highway system includes 5,578.9 miles, of which 3,032.3 miles have been improved with Federal aid. Of the improved mileage, 589.1 miles were added during the year. At the close of the year 644.1 miles were under construction.

The mileage improved with Federal aid consists of 476.8 miles of graded and drained earth roads, 1,612.5 miles of sand-clay, 828.5 miles of gravel, 13.8 miles of bituminous concrete, 74.6 miles of Portland cement concrete, and 19.6 miles of brick, in addition to which there are bridges with a total length of 6.5 miles.

The total cost of all Federal-aid roads completed during the year, including 387.8 miles of stage construction, was \$5,960,353.53, of which the

Federal share was \$2,781,546.22. The disbursement of Federal funds to the State was \$2,653,649.87. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,999,143.13.

NEVADA

The Federal-aid highway system includes 1,513 miles, of which 1,018.6 miles have been improved with Federal aid. Of the improved mileage, 106.2 miles were added during the year. At the close of the year 137.3 miles were under construction.

The mileage improved with Federal aid consists of 51.4 miles of graded and drained earth roads, 14 miles of sand-clay, 854.3 miles of gravel, 28.8 miles of water-bound macadam, 20.6 miles of bituminous macadam, 2 miles of bituminous concrete, and 44.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.6 miles.

The total cost of all Federal-aid roads completed during the year, including 27.4 miles of stage construction, was \$1,052,032.79, of which the Federal share was \$908,656.42. The disbursement of Federal funds to the State was \$937,054.96. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$595,556.89.

NEW HAMPSHIRE

The Federal-aid highway system includes 980.9 miles, of which 305.6 miles have been improved with Federal aid. Of the improved mileage, 37.1 miles were added during the year. At the close of the year 19 miles were under construction and 9.2 miles were approved.

The mileage improved with Federal aid consists of 99.2 miles of gravel, 66.2 miles of water-bound macadam, 88.6 miles of bituminous macadam, 32.9 miles of bituminous concrete, and 13.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 5 miles.

The total cost of all Federal-aid roads completed during the year, was \$1,208,093.27, of which the Federal share was \$544,659.08. The disbursement of Federal funds to the State was \$371,194.25. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$65,727.25.

NEW JERSEY

The Federal-aid highway system includes 1,181.7 miles, of which 418.3 miles have been improved with Federal aid. Of the improved mileage, 73.2 miles were added during the year. At the close of the year 71.3 miles were under construction.

The mileage improved with Federal aid consists of 8.9 miles of graded and drained earth roads, 4.7 miles of gravel, 21.9 miles of bituminous concrete, and 380.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year, was \$3,947,540.98, of which the Federal share was \$1,104,039.78. The disbursement of Federal funds to the State was \$1,319,535. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$253,177.

NEW MEXICO

The Federal-aid highway system includes 3,298 miles, of which 1,740.3 miles have been improved with Federal aid. Of the improved mileage, 180.1 miles were added during the year. At the close of the year 155.2 miles were under construction and 56.1 miles were approved.

The mileage improved with Federal aid consists of 244.2 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,416.6 miles of gravel, 0.7 mile of bituminous concrete, and 70.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed during the year was \$2,527,839.60, of which the Federal share was \$1,957,717.94. The disbursement of Federal funds to the State was \$1,417,762.65. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$894,813.28.

NEW YORK

The Federal-aid highway system includes 5,451 miles, of which 1,864.8 miles have been improved with Federal aid. Of the improved mileage, 385 miles were added during the year. At the close of the year 460.6 miles were under construction and 116.9 miles were approved.

The mileage improved with Federal aid consists of 12.9 miles of graded and

drained earth roads, 4.6 miles of sand-clay, 46.5 miles of gravel, 358.3 miles of bituminous macadam, 12.6 miles of bituminous concrete, 1,427.5 miles of Portland cement concrete, and 0.7 mile of brick, in addition to which there are bridges with a total length of 1.7 miles.

The total cost of all Federal-aid roads completed during the year, was \$19,211,852.17, of which the Federal share was \$6,002,773.59. The disbursement of Federal funds to the State was \$5,061,107.41. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$3,910,462.81.

NORTH CAROLINA

The Federal-aid highway system includes 3,959.9 miles, of which 1,582.4 miles have been improved with Federal aid. Of the improved mileage, 111 miles were added during the year. At the close of the year 89.7 miles were under construction and 5 miles were approved.

The mileage improved with Federal aid consists of 88.7 miles of graded and drained earth roads, 470 miles of sand-clay, 70.9 miles of gravel, 19.6 miles of water-bound macadam, 37.9 miles of bituminous macadam, 249.5 miles of bituminous concrete, and 643 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.8 miles.

The total cost of all Federal-aid roads completed during the year, including 34.4 miles of stage construction, was \$4,095,146.77, of which the Federal share was \$1,894,205.65. The disbursement of Federal funds to the State was \$1,589,297.53. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,141,531.23.

NORTH DAKOTA

The Federal-aid highway system includes 7,196 miles, of which 3,155.1 miles have been improved with Federal aid. Of the improved mileage, 469 miles were added during the year. At the close of the year 626.3 miles were under construction and 192.4 miles were approved.

The mileage improved with Federal aid consists of 1,259.6 miles of graded and drained earth roads, 21.1 miles of sand-clay, 1,855.5 miles of gravel, 5.3 miles of water-bound macadam, 1.9 miles of bituminous concrete, and 4.7

miles of Portland cement concrete, in addition to which there are bridges with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 398.7 miles of stage construction, was \$3,794,058.35, of which the Federal share was \$2,030,873.31. The disbursement of Federal funds to the State was \$1,409,404.82. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$637,992.37.

OHIO

The Federal-aid highway system includes 5,899.3 miles, of which 1,805.9 miles have been improved with Federal aid. Of the improved mileage, 261.4 miles were added during the year. At the close of the year 250.2 miles were under construction and 88.6 miles were approved.

The mileage improved with Federal aid consists of 65 miles of graded and drained earth roads, 6.7 miles of gravel, 135.1 miles of water-bound macadam, 367.9 miles of bituminous macadam, 93.9 miles of bituminous concrete, 669.7 miles of Portland cement concrete, and 465.5 miles of brick, in addition to which there are bridges with a total length of 2.1 miles.

The total cost of all Federal-aid roads completed during the year, including 4.2 miles of stage construction, was \$8,417,081.38, of which the Federal share was \$3,341,632.67. The disbursement of Federal funds to the State was \$2,183,363.28. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$2,591,001.85.

OKLAHOMA

The Federal-aid highway system includes 5,528 miles, of which 1,589.7 miles have been improved with Federal aid. Of the improved mileage, 211.7 miles were added during the year. At the close of the year 171 miles were under construction and 109.7 miles were approved.

The mileage improved with Federal aid consists of 303.1 miles of graded and drained earth roads, 2.3 miles of sand-clay, 605.6 miles of gravel, 6.3 miles of water-bound macadam, 30.8 miles of bituminous macadam, 78.6 miles of bituminous concrete, 542.6 miles of Portland cement concrete, and 8.9 miles of brick, in addition to which there are bridges with a total length of 11.5 miles.

The total cost of all Federal-aid roads completed during the year, including 32.3 miles of stage construction, was \$4,307,195.17, of which the Federal share was \$1,834,190.38. The disbursement of Federal funds to the State was \$1,618,293.19. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$387,602.49.

OREGON

The Federal-aid highway system includes 2,891.5 miles, of which 1,104.9 miles have been improved with Federal aid. Of the improved mileage 49.6 miles were added during the year. At the close of the year 40.7 miles were under construction and 6.7 miles were approved.

The mileage improved with Federal aid consists of 138.7 miles of graded and drained earth roads, 784.2 miles of gravel, 25.6 miles of water-bound macadam, 0.7 mile of bituminous macadam, 52.9 miles of bituminous concrete, and 99.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.9 miles.

The total cost of all Federal-aid roads completed during the year, including 38.6 miles of stage construction, was \$1,709,077.30, of which the Federal share was \$848,239.18. The disbursement of Federal funds to the State was \$658,467.98. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,267,098.47.

PENNSYLVANIA

The Federal-aid highway system includes 4,993.9 miles, of which 1,837 miles have been improved with Federal aid. Of the improved mileage, 197.7 miles were added during the year. At the close of the year 240.7 miles were under construction and 82.4 miles were approved.

The mileage improved with Federal aid consists of 104.2 miles of graded and drained earth roads, 18.4 miles of bituminous macadam, 101.2 miles of bituminous concrete, 1,586.2 miles of Portland cement concrete, and 26.4 miles of brick, in addition to which there are bridges with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year, including 3 miles of stage construction, was \$9,834,885.37, of which the Federal share was \$3,037,088.44. The dis-

bursement of Federal funds to the State was \$3,031,621.22. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,850,129.27.

RHODE ISLAND

The Federal-aid highway system includes 362.4 miles, of which 136.2 miles have been improved with Federal aid. Of the improved mileage, 18 miles were added during the year. At the close of the year 26.8 miles were under construction and 4 miles were approved.

The mileage improved with Federal aid consists of 1.8 miles of waterbound macadam, 25.2 miles of bituminous macadam, 47.2 miles of bituminous concrete, and 61.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed during the year was \$897,258.03, of which the Federal share was \$280,149.31. The disbursement of Federal funds to the State was \$318,506.03. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$576,046.16.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles, of which 1,631.6 miles have been improved with Federal aid. Of the improved mileage, 113.8 miles were added during the year. At the close of the year 205.5 miles were under construction and 10.4 miles were approved.

The mileage improved with Federal aid consists of 25.2 miles of graded and drained earth roads, 1,210.2 miles of sand-clay, 115.4 miles of gravel, 8.9 miles of water-bound macadam, 3 miles of bituminous macadam, 102.6 miles of bituminous concrete, 152.2 miles of Portland cement concrete, and 0.2 mile of brick, in addition to which there are bridges with a total length of 13.9 miles.

The total cost of all Federal-aid roads completed during the year, including 53.6 miles of stage construction, was \$3,591,684.06, of which the Federal share was \$1,182,549.75. The disbursement of Federal funds to the State was \$1,259,902.48. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$64,396.43.

SOUTH DAKOTA

The Federal-aid highway system includes 5,902 miles, of which 2,834.4 miles have been improved with Federal aid. Of the improved mileage, 289.5 miles were added during the year. At the close of the year 584 miles were under construction and 107 miles were approved.

The mileage improved with Federal aid consists of 224.1 miles of graded and drained earth roads, 25.7 miles of sand-clay, 2,579.2 miles of gravel, and 2.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.7 miles.

The total cost of all Federal-aid roads completed during the year, including 193.2 miles of stage construction, was \$2,039,746.84, of which the Federal share was \$1,122,233.53. The disbursement of Federal funds to the State was \$1,167,023.73. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$514,514.16.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles, of which 1,075.6 miles have been improved with Federal aid. Of the improved mileage, 100.3 miles were added during the year. At the close of the year 138.9 miles were under construction and 25.6 miles were approved.

The mileage improved with Federal aid consists of 157.1 miles of graded and drained earth roads, 123.8 miles of gravel, 52.2 miles of water-bound macadam, 428.8 miles of bituminous macadam, 33.5 miles of bituminous concrete, and 277.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.5 miles.

The total cost of all Federal-aid roads completed during the year, including 27.4 miles of stage construction, was \$3,483,124.90, of which the Federal share was \$1,496,826.48. The disbursement of Federal funds to the State was \$1,157,624.72. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$254,777.15.

TEXAS

The Federal-aid highway system includes 11,690.9 miles of which 5,965.9 miles have been improved with Federal aid. Of the improved mileage, 433.2

miles were added during the year. At the close of the year 224.8 miles were under construction and 161.9 miles were approved.

The mileage improved with Federal aid consists of 705.4 miles of graded and drained earth roads, 90.5 miles of sand-clay, 2,986.8 miles of gravel, 508.4 miles of water-bound macadam, 870.3 miles of bituminous macadam, 137.2 miles of bituminous concrete, 627.6 miles of Portland cement concrete, and 29.1 miles of brick, in addition to which there are bridges with a total length of 10.6 miles.

The total cost of all Federal-aid roads completed, during the year, including 246.7 miles of stage construction, was \$11,449,455.94, of which the Federal share was \$5,344,336.60. The disbursement of Federal funds to the States was \$4,367,659.10. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$3,975,468.70.

UTAH

The Federal-aid highway system includes 1,677.3 miles, of which 806.5 miles have been improved with Federal aid. Of the improved mileage, 97.6 miles were added during the year. At the close of the year 112.2 miles were under construction and 19.4 miles were approved.

The mileage improved with Federal aid consists of 94.7 miles of graded and drained earth roads, 41.7 miles of sand-clay, 548.9 miles of gravel, 16.8 miles of water-bound macadam, 0.7 mile of bituminous macadam, 9.9 miles of bituminous concrete, and 91.6 miles of Portland cement concrete, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year, including 7.5 miles of stage construction, was \$1,546,236.97, of which the Federal share was \$1,138,714.79. The disbursement of Federal funds to the State was \$1,290,052.52. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$220,749.79.

VERMONT

The Federal-aid highway system includes 1,043 miles, of which 201.3 miles have been improved with Federal aid. Of the improved mileage, 40.9 miles were added during the year. At the close of the year 51.2 miles were under

construction and 11.9 miles were approved.

The mileage improved with Federal aid consists of 96.4 miles of gravel, 8.2 miles of water-bound macadam, 45.6 miles of bituminous macadam, and 44.7 miles of Portland cement concrete, in addition to which there are bridges with a total length of 6.4 miles.

The total cost of all Federal-aid roads completed during the year was \$1,826,258.67, of which the Federal share was \$696,788.74. The disbursement of Federal funds to the State was \$694,117.53. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$25,473.81.

VIRGINIA

The Federal-aid highway system includes 3,251.7 miles, of which 1,266.9 miles have been improved with Federal aid. Of the improved mileage, 105.6 miles were added during the year. At the close of the year 99.3 miles were under construction and 31.6 miles were approved.

The mileage improved with Federal aid consists of 55 miles of graded and drained earth roads, 192.5 miles of sand-clay, 119.9 miles of gravel, 112.3 miles of water-bound macadam, 306.6 miles of bituminous macadam, 10.6 miles of bituminous concrete, and 466.2 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.8 miles.

The total cost of all Federal-aid roads completed during the year, including 3.9 miles of stage construction, was \$4,588,477.73, of which the Federal share was \$1,893,029.67. The disbursement of Federal funds to the State was \$1,439,060.08. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$237,853.61.

WASHINGTON

The Federal-aid highway system includes 2,927.5 miles, of which 777.7 miles have been improved with Federal aid. Of the improved mileage, 73.6 miles were added during the year. At the close of the year 105.4 miles were under construction and 21.2 miles were approved.

The mileage improved with Federal aid consists of 145.7 miles of graded and drained earth roads, 344 miles of gravel, and 283.9 miles of Portland cement concrete, in addition to which

there are bridges with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year was \$3,637,496.70, of which the Federal share was \$1,649,901.70. The disbursement of Federal funds to the State was \$521,599.31. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$481,843.46.

WEST VIRGINIA

The Federal-aid highway system includes 2,094.9 miles, of which 606.9 miles have been improved with Federal aid. Of the improved mileage, 132.9 miles were added during the year. At the close of the year 105.6 miles were under construction and 25.3 miles were approved.

The mileage improved with Federal aid consists of 227.4 miles of graded and drained earth roads, 3.9 miles of sand-clay, 19.9 miles of gravel, 4.9 miles of water-bound macadam, 159.7 miles of bituminous macadam, 28.2 miles of bituminous concrete, 150.2 miles of Portland cement concrete, and 11.4 miles of brick, in addition to which there are bridges with a total length of 1.3 miles.

The total cost of all Federal-aid roads completed during the year, including 4 miles of stage construction, was \$3,778,799.97, of which the Federal share was \$1,548,876.64. The disbursement of Federal funds to the State was \$1,043,717. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$478,768.16.

WISCONSIN

The Federal-aid highway system includes 5,493.4 miles, of which 2,046.9 miles have been improved with Federal aid. Of the improved mileage, 323.7 miles were added during the year. At the close of the year 277.2 miles were under construction and 36.5 miles were approved.

The mileage improved with Federal aid consists of 208.6 miles of graded and drained earth roads, 104.4 miles of sand-clay, 1,042.2 miles of gravel, 6.8 miles of water-bound macadam, 13.7 miles of bituminous macadam, and 669.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year, including 36.1 miles of stage construction, was \$8,482,428.81, of which the Federal share was \$3,983,658.48. The disbursement of Federal funds to the State was \$2,959,014.72. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,435,440.82.

WYOMING

The Federal-aid highway system includes 3,097, of which 1,442.5 miles have been improved with Federal aid. Of the improved mileage, 124.5 miles were added during the year. At the close of the year 227 miles were under construction and 41.8 miles were approved.

The mileage improved with Federal aid consists of 383.2 miles of graded and drained earth roads, 484.2 miles of sand-clay, 516.8 miles of gravel, 15.5 miles of water-bound macadam, 22.1 miles of bituminous concrete, and 15.9 miles of Portland cement concrete, in addition to which there are bridges with a total length of 4.8 miles.

The total cost of all Federal-aid roads completed during the year, including 68.7 miles of stage construction, was \$1,313,556.03, of which the Federal share was \$849,085.28. The disbursement of Federal funds to the State was \$1,106,907.83. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$167,116.50.

HAWAII

The Federal-aid highway system includes 174.6 miles of which 36.2 miles have been improved with Federal aid. Of the improved mileage 29.7 miles were added during the year. At the close of the year 3.2 miles were under construction and 1.8 miles were approved.

The mileage improved with Federal aid consists of 20.3 miles of bituminous macadam, and 15.8 miles of Portland cement concrete, in addition to which there are bridges with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed during the year was \$1,773,962.02, of which the Federal share was \$551,836.79. The disbursement of Federal funds to the State was \$325,901.59. The unobligated balance available on June 30, 1928, of all appropriations authorized and apportioned up to that date was \$1,064,241.58.

FEDERAL-AID STATISTICS

Statistical information relative to the apportionment, obligation, and disbursement of Federal aid during the fiscal year 1928; the cost of roads completed and the estimated cost of roads under construction; and the type of roads completed and under construction, etc., is given in Tables 7 to 19, inclusive.

TABLE 7.—*Mileage of the designated Federal-aid highway system in each State and mileage improved with Federal aid to June 30, 1928*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1928
Alabama.....	3,884.0	1,748.0
Arizona.....	1,498.0	851.4
Arkansas.....	5,021.1	1,678.2
California.....	4,771.5	1,455.6
Colorado.....	3,332.0	979.3
Connecticut.....	835.4	206.5
Delaware.....	431.5	195.7
Florida.....	1,926.0	385.8
Georgia.....	5,576.7	2,457.5
Idaho.....	2,770.0	937.1
Illinois.....	6,618.5	1,685.4
Indiana.....	4,701.5	1,060.1
Iowa.....	7,212.0	2,831.5
Kansas.....	7,925.0	2,202.4
Kentucky.....	3,702.5	1,148.9
Louisiana.....	2,712.9	1,276.0
Maine.....	1,428.9	428.7

TABLE 7.—*Mileage of the designated Federal-aid highway, etc.—Contd.*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1928
Maryland.....	1,527.7	557.5
Massachusetts.....	1,308.0	501.1
Michigan.....	5,243.0	1,337.3
Minnesota.....	6,849.6	3,823.8
Mississippi.....	3,604.0	1,533.6
Missouri.....	7,530.0	2,210.1
Montana.....	4,673.5	1,299.3
Nebraska.....	5,578.9	3,032.3
Nevada.....	1,513.0	1,018.6
New Hampshire.....	980.9	305.6
New Jersey.....	1,181.7	418.3
New Mexico.....	3,298.0	1,740.3
New York.....	5,451.0	1,864.8
North Carolina.....	3,659.9	1,582.4
North Dakota.....	7,196.0	3,155.1
Ohio.....	5,829.3	1,805.9
Oklahoma.....	5,528.0	1,589.7
Oregon.....	2,891.5	1,104.9
Pennsylvania.....	4,993.9	1,537.0
Rhode Island.....	352.4	136.2
South Carolina.....	3,230.0	1,631.6
South Dakota.....	5,902.0	2,834.4
Tennessee.....	3,252.8	1,075.6
Texas.....	11,690.9	5,965.9
Utah.....	1,677.3	806.5
Vermont.....	1,043.0	201.3
Virginia.....	3,251.7	1,266.9
Washington.....	2,927.5	777.7
West Virginia.....	2,094.9	606.9
Wisconsin.....	5,493.4	2,046.9
Wyoming.....	3,097.0	1,442.5
Hawaii.....	174.6	36.2
Total.....	187,752.9	71,074.3

TABLE 8.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1928*

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
Alabama.....	\$4,495,050.49	\$2,178,119.49	310.0	1.9	311.9
Arizona.....	655,349.80	467,215.24	16.1	.....	16.1
Arkansas.....	954,845.03	445,342.40	90.7	.....	90.7
California.....	4,395,894.90	1,771,379.44	98.5	.....	98.5
Colorado.....	905,351.91	455,668.30	24.9	3.2	28.1
Connecticut.....	3,906,025.81	1,124,080.50	55.5	.....	55.5
Delaware.....	808,932.97	361,314.04	35.0	.....	35.0
Florida.....	3,497,532.47	1,556,930.83	75.6	.....	75.6
Georgia.....	4,846,753.53	2,227,438.42	118.2	90.9	209.1
Idaho.....	1,187,587.69	729,934.10	43.5	32.2	75.7
Illinois.....	3,918,735.90	1,901,874.76	142.2	.....	142.2
Indiana.....	6,007,355.89	2,915,222.26	222.1	.....	222.1
Iowa.....	8,915,667.75	4,115,257.62	378.8	84.7	463.5
Kansas.....	9,592,174.56	4,023,845.38	578.3	18.0	596.3
Kentucky.....	5,421,784.29	2,361,246.84	250.9	30.7	281.6
Louisiana.....	2,647,414.58	1,086,023.19	61.5	7.5	69.0
Maine.....	2,319,089.55	805,501.50	65.8	.....	65.8
Maryland.....	1,481,188.35	696,177.50	75.6	.....	75.6
Massachusetts.....	2,957,259.58	957,873.69	60.5	.....	60.5
Michigan.....	5,431,692.50	2,369,018.36	175.8	.....	175.8
Minnesota.....	5,852,424.86	2,001,398.90	248.7	110.3	359.0
Mississippi.....	4,633,642.00	2,246,390.87	187.8	36.0	223.8
Missouri.....	4,004,271.51	2,099,546.14	171.7	22.1	193.8
Montana.....	1,734,065.14	1,133,573.73	142.1	9.2	151.3
Nebraska.....	5,960,353.53	2,781,546.22	589.1	387.8	976.9
Nevada.....	1,052,032.79	908,656.42	106.2	27.4	133.6
New Hampshire.....	1,208,093.27	544,659.08	37.1	.....	37.1

TABLE 8.—Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1928—Continued

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
New Jersey.....	\$3,947,540.98	\$1,104,039.78	73.2	-----	73.2
New Mexico.....	2,527,839.60	1,957,717.94	180.1	-----	180.1
New York.....	19,211,852.17	6,002,773.59	385.0	-----	385.0
North Carolina.....	4,095,146.77	1,894,205.65	111.0	34.4	145.4
North Dakota.....	3,794,058.35	2,030,873.31	469.0	398.7	867.7
Ohio.....	8,417,081.38	3,341,632.67	261.4	4.2	265.6
Oklahoma.....	4,307,195.17	1,834,190.38	211.7	32.3	244.0
Oregon.....	1,709,077.30	848,239.18	49.6	38.6	88.2
Pennsylvania.....	9,834,885.37	3,037,088.44	197.7	3.0	200.7
Rhode Island.....	897,258.03	280,149.31	18.0	-----	18.0
South Carolina.....	3,591,684.06	1,182,549.75	113.8	53.6	167.4
South Dakota.....	2,039,746.84	1,122,233.53	289.5	193.2	482.7
Tennessee.....	3,483,124.90	1,496,826.48	100.3	27.4	127.7
Texas.....	11,449,455.94	5,344,336.60	433.2	246.7	679.9
Utah.....	1,546,236.97	1,138,714.79	97.6	7.5	105.1
Vermont.....	1,826,258.67	696,788.74	40.9	-----	40.9
Virginia.....	4,588,477.73	1,893,029.67	105.6	3.9	109.5
Washington.....	3,637,496.70	1,649,901.70	73.6	-----	73.6
West Virginia.....	3,778,799.97	1,548,876.64	132.9	4.0	136.9
Wisconsin.....	8,482,428.81	3,983,665.48	323.7	36.1	359.8
Wyoming.....	1,313,556.03	849,085.28	124.5	68.7	193.2
Hawaii.....	1,773,962.02	551,836.79	29.7	-----	29.7
Total.....	205,043,784.41	88,056,983.92	8,134.2	2,014.2	10,198.4

TABLE 9.—Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1928, by States

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama.....	\$5,195,635.95	\$2,583,180.18	270.5	55.9	326.4
Arizona.....	1,795,361.35	1,577,922.94	86.0	.6	86.6
Arkansas.....	4,906,901.45	2,174,942.33	180.7	-----	180.7
California.....	6,122,281.76	2,929,250.54	120.7	8.2	128.9
Colorado.....	5,134,698.11	2,627,641.63	189.4	9.2	198.6
Connecticut.....	3,269,777.06	831,098.01	34.4	-----	34.4
Delaware.....	470,022.22	95,739.75	5.7	3.9	9.6
Florida.....	4,185,912.27	1,773,093.63	99.7	5.4	105.1
Georgia.....	3,701,359.50	1,805,098.52	168.2	30.7	198.9
Idaho.....	2,067,804.47	1,235,873.81	116.5	56.8	173.3
Illinois.....	19,966,945.33	9,204,790.58	620.1	-----	620.1
Indiana.....	10,285,596.57	4,915,301.36	314.2	3.5	317.7
Iowa.....	7,006,259.73	2,993,700.52	145.2	137.3	282.5
Kansas.....	4,812,182.97	1,907,366.82	242.8	-----	242.8
Kentucky.....	4,924,557.22	2,488,415.88	227.4	-----	227.4
Louisiana.....	4,161,328.09	2,072,905.40	193.0	-----	193.0
Maine.....	1,294,982.17	528,952.60	39.7	-----	39.7
Maryland.....	738,690.77	353,730.00	30.0	-----	30.0
Massachusetts.....	3,785,205.01	1,133,667.82	71.4	-----	71.4
Michigan.....	13,340,940.37	5,616,223.08	328.5	-----	328.5
Minnesota.....	6,287,137.06	2,088,100.00	305.9	54.7	360.6
Mississippi.....	4,361,785.79	2,149,654.95	228.3	30.9	259.2
Missouri.....	4,630,204.01	1,900,212.49	132.8	39.0	171.8
Montana.....	3,526,790.69	2,385,241.58	275.6	4.1	279.7
Nebraska.....	6,436,612.14	3,206,959.06	644.1	197.4	841.5
Nevada.....	1,156,011.48	1,012,597.47	137.3	28.4	165.7
New Hampshire.....	661,935.44	272,453.16	19.0	-----	19.0
New Jersey.....	5,847,748.19	1,039,947.35	71.3	-----	71.3
New Mexico.....	2,414,979.86	1,602,034.50	155.2	-----	155.2
New York.....	30,549,500.00	7,164,693.95	460.6	-----	460.6
North Carolina.....	2,052,044.50	981,951.81	89.7	13.0	102.7
North Dakota.....	3,660,655.06	1,740,332.78	626.3	165.4	791.7
Ohio.....	11,260,370.37	4,150,846.38	250.2	6.0	256.2
Oklahoma.....	3,367,788.78	1,617,074.66	171.0	6.4	177.4
Oregon.....	1,517,571.16	847,554.19	40.7	-----	40.7
Pennsylvania.....	13,745,519.18	3,983,882.84	240.7	-----	240.7
Rhode Island.....	1,723,452.42	431,049.92	26.8	-----	26.8
South Carolina.....	8,499,229.16	1,887,138.22	205.5	120.7	326.2
South Dakota.....	3,458,251.40	1,855,200.66	584.0	73.3	657.3

TABLE 9.—Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1928, by States—Contd.

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Tennessee.....	\$4,524,754.78	\$1,939,405.06	138.9	-----	138.9
Texas.....	8,914,648.60	3,494,782.06	224.8	125.1	349.9
Utah.....	1,996,561.57	1,364,094.82	112.2	12.3	124.5
Vermont.....	2,345,384.25	584,978.39	51.2	-----	51.2
Virginia.....	4,221,703.93	1,337,952.75	99.3	21.6	120.9
Washington.....	4,144,458.77	1,437,080.00	105.4	18.1	123.5
West Virginia.....	2,789,397.94	1,244,328.22	105.6	-----	105.6
Wisconsin.....	7,931,130.44	3,251,570.37	277.2	25.2	302.4
Wyoming.....	2,260,697.90	1,417,612.15	227.0	32.1	259.1
Hawaii.....	301,973.75	60,383.43	3.2	-----	3.2
Total.....	261,754,800.99	105,297,930.62	9,493.9	1,285.2	10,779.1

TABLE 10.—Total cost, Federal aid, and mileage of Federal-aid roads, initial and stage construction, approved for construction, as of June 30, 1928, by States

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama.....	\$717,945.71	\$358,972.83	48.7	12.4	61.1
Arizona.....	122,094.33	42,024.80	-----	4.2	4.2
Arkansas.....	250,474.26	102,444.55	9.9	6.2	16.1
California.....	1,573,168.56	703,031.15	43.7	-----	43.7
Colorado.....	287,928.34	159,230.93	12.7	14.5	27.2
Connecticut.....	285,289.67	66,951.17	3.6	-----	3.6
Delaware.....	310,591.60	155,295.80	12.9	-----	12.9
Florida.....	905,396.31	333,505.44	30.7	-----	30.7
Georgia.....	2,934,550.18	1,239,573.27	102.3	50.1	152.4
Idaho.....	1,100,504.72	653,836.57	101.6	1.8	103.4
Illinois.....	3,896,721.88	1,942,068.60	148.0	-----	148.0
Indiana.....	1,671,729.13	807,135.04	61.3	-----	61.3
Iowa.....	1,827,757.31	778,011.52	10.2	71.4	81.6
Kansas.....	1,348,337.76	598,232.45	106.3	-----	106.3
Kentucky.....	1,159,696.00	579,848.00	62.7	-----	62.7
Louisiana.....	724,325.88	239,803.83	8.8	-----	8.8
Maine.....	586,603.30	200,682.36	14.2	-----	14.2
Maryland.....	858,354.80	416,900.00	58.6	7.2	65.8
Massachusetts.....	361,296.54	84,345.00	5.6	-----	5.6
Michigan.....	1,150,043.70	525,885.00	29.4	6.5	35.9
Minnesota.....	1,201,168.05	291,000.00	49.8	20.6	70.4
Mississippi.....	201,358.23	100,459.53	11.5	6	12.1
Missouri.....	1,511,404.60	602,718.59	46.3	13.7	60.0
Montana.....	2,345,539.14	1,308,589.18	235.1	10.7	245.8
Nebraska.....	75,620.57	37,768.83	-----	23.2	23.2
Nevada.....	59,079.34	51,419.58	-----	23.7	23.7
New Hampshire.....	490,414.66	190,235.78	9.2	-----	9.2
New Mexico.....	777,265.15	492,343.74	56.1	5	56.6
New York.....	8,328,900.00	1,806,847.50	116.9	8.6	125.5
North Carolina.....	534,495.97	259,500.00	5.0	19.5	24.5
North Dakota.....	1,240,836.15	502,502.23	192.4	121.7	314.1
Ohio.....	4,757,780.00	1,340,636.26	88.6	6.7	95.3
Oklahoma.....	1,871,838.77	837,936.01	109.7	15.5	125.2
Oregon.....	278,334.10	146,673.72	6.7	-----	6.7
Pennsylvania.....	4,414,639.79	1,318,026.22	82.4	-----	82.4
Rhode Island.....	311,081.95	80,919.55	4.0	-----	4.0
South Carolina.....	394,006.44	69,700.00	10.4	8.1	18.5
South Dakota.....	655,789.73	360,684.24	107.0	39.2	146.2
Tennessee.....	4,267,517.00	1,368,324.58	25.6	94.3	119.9
Texas.....	6,241,573.47	2,627,108.00	161.9	156.0	317.9
Utah.....	328,886.36	240,095.90	19.4	1.5	20.9
Vermont.....	584,323.08	147,454.36	11.9	-----	11.9
Virginia.....	884,718.69	156,605.91	31.6	-----	31.6
Washington.....	1,142,840.68	440,236.89	21.2	5.0	26.2
West Virginia.....	617,098.44	294,283.84	25.3	-----	25.3
Wisconsin.....	1,400,034.42	433,988.43	36.5	15.7	52.2
Wyoming.....	296,051.33	190,064.91	41.8	-----	41.8
Hawaii.....	175,931.99	57,501.20	1.8	-----	1.8
Total.....	67,461,518.09	25,741,403.29	2,359.3	759.1	3,118.4

TABLE 11.—Mileage of Federal-aid roads improved as of June 30, 1928, by types of construction

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	65.7	524.7	886.8	11.6	74.1	87.5	91.8		5.8	1,748.0
Arizona	124.7	115.8	458.2	14.2		26.6	108.9		3.0	851.4
Arkansas	11.3	3.0	1,122.3	48.3	112.2	256.3	120.9		3.9	1,678.2
California	315.8		357.0	18.7	63.7	141.6	553.0		5.8	1,455.6
Colorado	226.2	96.2	426.5			4.0	219.4		7.0	979.3
Connecticut			.2	17.4	27.0	.6	158.9		2.4	206.5
Delaware				5.0	7.0	13.7	167.2	2.3	.5	195.7
Florida	9.0	15.7	69.8	29.8	78.9	42.0	123.4	10.1	7.1	385.8
Georgia	210.5	1,173.4	413.6	86.9	134.3	26.8	384.4	.5	27.1	2,457.5
Idaho	185.2	13.9	592.0	22.5	4.9	79.3	36.3		3.0	937.1
Illinois	110.3		.4		3.4	8.1	1,536.0	25.8	1.4	1,685.4
Indiana	13.5		42.2	41.6	23.4	12.0	917.2	6.6	3.6	1,060.1
Iowa	1,455.6		566.2				786.0	22.0	1.7	2,831.5
Kansas	877.3	217.1	229.8	4.5	113.9	3.5	590.0	153.9	12.4	2,202.4
Kentucky	522.0		246.1	41.3	182.2	1.0	150.2	3.9	2.2	1,148.9
Louisiana	25.6		1,173.3	3.2	9.5	33.5	22.8		8.1	1,276.0
Maine			192.0		157.2		79.1		.4	428.7
Maryland	4.7		31.5	.2	200.1	17.0	304.0			557.5
Massachusetts			.4	3.5	259.2	50.5	183.1		4.4	501.1
Michigan	10.4		364.5	18.9	10.4	73.4	857.7	.4	1.6	1,337.3
Minnesota	656.4	6.2	2,522.3			32.7	605.5		.7	3,823.8
Mississippi	212.4	16.6	1,081.5	11.1	1.0	9.5	186.1	9.7	5.7	1,533.6
Missouri	375.3		844.7	7.4	50.8	17.7	884.1	20.9	9.2	2,210.1
Montana	219.5	5.6	1,011.0	17.8	6.9	2.8	31.9		3.8	1,299.3
Nebraska	476.8	1,612.5	828.5			13.8	74.6	19.6	6.5	3,032.3
Nevada	51.4	14.0	854.3	28.8	20.6	2.0	44.9		2.6	1,018.6
New Hampshire			99.2	66.2	88.6	32.9	13.7		5.0	305.6
New Jersey	8.9		4.7			21.9	380.5		2.3	418.3
New Mexico	244.2	5.1	1,416.6			.7	70.9		2.8	1,740.3
New York	12.9	4.6	46.5		358.3	12.6	1,427.5	.7	1.7	1,864.8
North Carolina	88.7	470.0	70.9	19.6	37.9	249.5	643.0		2.8	1,582.4
North Dakota	1,259.6	21.1	1,855.5	5.3		1.9	4.7		7.0	3,155.1
Ohio	65.0		6.7	135.1	367.9	93.9	669.7	465.5	2.1	1,805.9
Oklahoma	303.1	2.3	605.6	6.3	30.8	78.6	542.6	8.9	11.5	1,589.7
Oregon	138.7		784.2	25.6	.7	52.9	99.9		2.9	1,104.9
Pennsylvania	104.2				18.4	101.2	1,586.2	26.4	.6	1,837.0
Rhode Island				1.8	25.2	47.2	61.9		.1	136.2
South Carolina	25.2	1,210.2	115.4	8.9	3.0	102.6	152.2	.2	13.9	1,631.6
South Dakota	224.1	25.7	2,579.2				2.7		2.7	2,834.4
Tennessee	157.1		123.8	52.2	428.8	33.5	277.7		2.5	1,075.6
Texas	705.4	90.5	2,986.8	508.4	870.3	137.2	627.6	29.1	10.6	5,965.9
Utah	94.7	41.7	548.9	16.8	.7	9.9	91.6		2.2	806.5
Vermont			96.4	8.2	45.6		44.7		6.4	201.3
Virginia	55.0	192.5	119.9	112.3	306.6	10.6	466.2		3.8	1,266.9
Washington	145.7		344.0				283.9		4.1	777.7
West Virginia	227.4	3.9	19.9	4.9	159.7	28.2	150.2	11.4	1.3	606.9
Wisconsin	208.6	104.4	1,042.2	6.8	13.7		669.8		1.4	2,046.9
Wyoming	383.2	484.2	516.8	15.5		22.1	15.9		4.8	1,442.5
Hawaii					20.3		15.8		.1	36.2
Total	10,611.3	6,470.9	27,698.3	1,426.6	4,317.2	1,993.3	17,516.3	817.9	222.5	71,074.3

TABLE 12.—*Mileage of Federal-aid roads initially completed during the fiscal year 1928, by types of construction*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama.....	49.2	111.5	107.8	-----	20.9	-----	18.1	-----	2.6	310.1
Arizona.....	4.7	-----	10.6	-----	-----	-----	.4	-----	.4	16.1
Arkansas.....	11.3	-----	62.9	-----	13.3	-----	2.7	-----	.6	96.8
California.....	3.7	-----	8.5	0.5	.5	61.4	23.1	-----	.8	95.5
Colorado.....	-2.6	-9.5	24.3	-----	-----	-----	11.7	-----	1.0	24.9
Connecticut.....	-----	-----	-----	8.7	-----	.6	44.0	-----	2.1	55.4
Delaware.....	-----	-----	-----	-----	7.0	13.7	14.1	-----	.2	35.0
Florida.....	-1.8	-----	23.2	23.1	6.3	.1	19.5	-----	4.1	75.5
Georgia.....	62.0	4.5	12.0	11.8	-9	.9	24.8	-----	2.7	118.1
Idaho.....	-10.4	-----	49.8	-----	-----	2.7	142.4	-----	1.0	49.5
Illinois.....	-----	-----	8.6	-----	-----	-----	142.2	-----	-----	142.2
Indiana.....	-----	-----	19.7	-15.1	6.4	-----	234.6	6.6	.7	222.1
Iowa.....	196.9	-----	19.7	-----	-----	-----	167.7	-----	.5	375.8
Kansas.....	390.1	70.9	31.7	-----	16.2	-----	102.2	14.1	3.2	578.4
Kentucky.....	144.3	-----	58.9	-----	24.6	-----	24.3	-----	1.6	250.9
Louisiana.....	.5	-----	28.8	-----	-----	15.5	12.1	-----	4.6	61.5
Maine.....	-----	-----	30.1	-----	1.9	-----	27.6	-----	.1	65.7
Maryland.....	-----	-----	-----	-----	47.6	-----	28.0	-----	-----	75.6
Massachusetts.....	-----	-----	.4	-----	31.5	13.8	14.8	-----	-----	60.5
Michigan.....	10.0	-----	34.6	-----	-----	-----	130.3	-----	.9	175.8
Minnesota.....	231.1	-----	6.1	-----	-----	-----	11.3	-----	.2	248.7
Mississippi.....	60.4	-----	91.1	-----	-----	-----	30.9	.5	5.0	157.9
Missouri.....	56.5	-----	5.5	-----	-----	-----	109.7	-----	-----	171.7
Montana.....	15.6	-----	122.7	1.9	-----	-----	.6	-----	1.3	142.1
Nebraska.....	23.4	581.4	-38.7	-----	-----	2.9	18.4	.9	.7	589.0
Nevada.....	-----	-----	102.0	4.8	-----	-----	-----	-----	-6	106.2
New Hampshire.....	-----	-----	.1	12.4	19.1	.2	5.9	-----	2.4	37.1
New Jersey.....	2.8	-----	.1	-----	-----	-----	70.3	-----	-----	73.2
New Mexico.....	.8	-----	177.4	-----	-----	-----	.7	-----	1.2	180.1
New York.....	10.5	4.6	23.8	-----	13.3	-----	332.6	-----	.2	385.0
North Carolina.....	-----	-----	-----	-----	-----	-----	110.3	-----	.7	111.0
North Dakota.....	249.7	10.8	107.5	-----	-----	-----	-----	-----	1.0	469.0
Ohio.....	34.1	-----	-----	31.8	47.8	-----	126.3	20.0	1.4	261.4
Oklahoma.....	122.0	-----	-----	-----	9.9	-2.9	82.8	-----	-----	211.8
Oregon.....	32.0	-----	17.4	-----	-----	-----	-----	-----	.2	49.6
Pennsylvania.....	14.5	-----	-----	-----	10.6	-----	172.0	-----	.6	197.7
Rhode Island.....	-----	-----	-----	-----	7.7	-----	10.3	-----	-----	18.0
South Carolina.....	4.2	69.5	6.3	-----	-----	7.4	23.6	-----	2.9	113.9
South Dakota.....	-12.6	-----	300.0	-----	-----	-----	1.5	-----	.6	289.5
Tennessee.....	35.3	-----	6.8	-----	12.2	5.8	38.9	-----	1.0	100.4
Texas.....	221.4	-----	57.8	-----	107.4	6.8	37.1	-----	2.6	433.1
Utah.....	.5	-----	69.7	-----	-----	-----	-----	-----	.4	67.6
Vermont.....	-----	-----	-3.4	4.8	15.5	-----	23.4	-----	.6	40.9
Virginia.....	-----	-----	-----	3.7	2.9	-----	97.5	-----	1.5	105.6
Washington.....	38.6	-----	22.9	-----	-----	-----	12.2	-----	1.9	73.6
West Virginia.....	66.7	-----	-----	-----	31.3	7.0	27.2	-----	.7	132.9
Wisconsin.....	-----	-----	170.2	4.0	-----	-----	149.4	-----	-----	338.6
Wyoming.....	73.7	-----	46.1	-----	-----	-----	1.1	-----	.6	124.5
Hawaii.....	-----	-----	-----	-----	13.8	-----	15.8	-----	.1	29.7
Total.....	2,182.3	844.0	1,896.3	62.4	464.2	135.9	2,532.7	42.1	54.3	8,184.2

TABLE 13.—Mileage of Federal-aid roads under initial construction on June 30, 1928, by types of construction

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	146.0	18.4	72.6				31.2		2.3	270.5
Arizona	80.5		1.3			3.0	4.5		1.7	86.0
Arkansas	66.9		81.1		4.3		24.5		3.9	180.7
California	36.7		42.0	9.1	1.7	15.7	14.3		1.2	120.7
Colorado	32.4	16.5	82.5				55.9		2.1	189.4
Connecticut					12.6		20.3		1.5	34.4
Delaware							5.7			5.7
Florida	28.1		15.8	10.0	12.9	11.8	19.8		1.3	99.7
Georgia	51.1	24.1	6.3	21.6	23.0	16.3	25.3		.5	168.2
Idaho			92.1		15.5	5.1	3.4		.4	116.5
Illinois	76.5						535.2	6.2	2.2	620.1
Indiana	23.6						290.0		.6	314.2
Iowa	5.7		34.4				104.9		.2	145.2
Kansas	116.3	48.9	10.0		11.5		53.4	1.0	1.7	242.8
Kentucky	151.5		3.7		45.6		21.7		4.9	227.4
Louisiana	44.5		126.8				16.8		4.9	193.0
Maine			23.2		9.5		5.9		1.1	39.7
Maryland					14.8		15.2			30.0
Massachusetts				.4	42.4	19.0	9.5		.1	71.4
Michigan	25.9		23.4				277.5		1.7	328.5
Minnesota	270.4						35.1		.4	305.9
Mississippi	105.7		89.9			1.4	28.4		2.9	228.3
Missouri	97.0						35.1		.7	132.8
Montana	30.2		241.0				3.8		.6	275.6
Nebraska	182.7	457.5					2.4		1.5	644.1
Nevada	8.2		129.1							137.3
New Hampshire				5.5	2.4		11.1			19.0
New Jersey	1.7		.7		.2	.4	68.3			71.3
New Mexico	12.5		91.3	41.7			9.0		.7	155.2
New York	36.6		19.5		33.0		371.1		.4	460.6
North Carolina	33.7						55.6		.4	89.7
North Dakota	541.0	3.0	64.7	16.2					1.4	626.3
Ohio	58.2		1.7	7.8	34.9	3.4	114.9	27.2	2.1	250.2
Oklahoma	129.7				10.4		30.1		.8	171.0
Oregon	15.3		24.6						.8	40.7
Pennsylvania	48.7						177.0	13.3	1.7	240.7
Rhode Island					19.0		7.8			26.8
South Carolina	29.0	71.7	10.9			17.4	72.7		3.8	205.5
South Dakota	356.8		226.6						.6	584.0
Tennessee	100.7					7.0	29.2		2.0	138.9
Texas	131.1		14.6	3.9			73.5		1.7	224.8
Utah	29.5		73.9		4.5		4.1		.2	112.2
Vermont			6.8		5.9		38.3		.2	51.2
Virginia				8.4	63.7		26.5		.7	99.3
Washington	52.9		45.8				6.5		.2	105.4
West Virginia	69.1		5.4		11.1		19.8		.2	105.6
Wisconsin		8.1	135.1				132.2		1.8	277.2
Wyoming	175.1		35.8	11.4			4.1		.6	227.0
Hawaii							3.2			3.2
Total	3,401.5	648.2	1,831.6	136.0	378.9	100.5	2,890.8	47.7	58.7	9,493.9

TABLE 14.—*Mileage of Federal-aid roads approved for initial construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	27.3		21.3						0.1	48.7
Arkansas	9.9									9.9
California			20.0	20.2		1.7	1.5		.3	43.7
Colorado			7.4	5.3						12.7
Connecticut							3.6			3.6
Delaware				8.0			4.9			12.9
Florida	12.6				18.0				.1	30.7
Georgia				15.4	82.8		4.1			102.3
Idaho	22.0		72.7				6.9			101.6
Illinois	36.8						111.2			148.0
Indiana	8.4						52.9			61.3
Iowa	1.4		1.7				7.1			10.2
Kansas	80.1						25.9		.3	106.3
Kentucky	62.3						.4			62.7
Louisiana	5.3								3.5	8.8
Maine			6.6		1.0		6.4		.2	14.2
Maryland					16.6	12.1	9.9			38.6
Massachusetts					5.6					5.6
Michigan							29.0		.4	29.4
Minnesota	44.0						5.6		.2	49.8
Mississippi			11.5							11.5
Missouri	20.6		5.5				19.9		.3	46.3
Montana	32.1		182.0	20.3					.7	235.1
New Hampshire							9.1		.1	9.2
New Mexico	15.3		40.5				.3			56.1
New York					27.4		89.5			116.9
North Carolina							5.0			5.0
North Dakota	191.4						.8		.2	192.4
Ohio	14.1						71.0	3.4		88.6
Oklahoma	86.2				10.1		13.1		.3	109.7
Oregon	6.6								.1	6.7
Pennsylvania	2.6						79.7		.1	82.4
Rhode Island						2.5	1.5			4.0
South Carolina							10.4			10.4
South Dakota	84.8	9.2	12.9						.1	107.0
Tennessee	21.1						4.5			25.6
Texas	128.9				.9		30.4		1.7	161.9
Utah			15.0				4.4			19.4
Vermont							11.9			11.9
Virginia	6.6		.2		24.8					31.6
Washington	17.4						3.6		.2	21.2
West Virginia	19.4				5.9					25.3
Wisconsin			16.9				19.6			36.5
Wyoming	41.8									41.8
Hawaii	1.7								.1	1.8
Total	1,000.7	9.2	414.2	69.2	193.1	16.3	644.1	3.4	9.1	2,359.3

TABLE 15.—*Mileage of Federal-aid stage construction completed during the fiscal year 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama							1.9			1.9
Arizona	-4.3		4.3							
Colorado			2.9				.3			3.2
Florida			11.8	-11.8						
Georgia	.9		.2		12.0		77.8			90.9
Idaho			-1.8	18.2		15.5	.4			32.2
Iowa			-19.5				104.2			84.7
Kansas	.4	3.5					8.7	5.4		18.0
Kentucky			26.6		4.1					30.7
Louisiana						7.5				7.5
Minnesota							110.3			110.3
Mississippi			14.1				21.9			36.0
Missouri	5.7		.1				16.3			22.1
Montana			9.2							9.2
Nebraska		386.3					1.2		0.2	387.8
Nevada			13.4	13.9						27.4
North Carolina							34.4			34.4
North Dakota			394.4	4.3						398.7
Ohio							3.5	.7		4.2
Oklahoma					12.5		19.8			32.3
Oregon			38.6							38.6
Pennsylvania							3.0			3.0
South Carolina						6.2	47.4			53.6
South Dakota		7.6	185.6							193.2
Tennessee							27.4			27.4
Texas	11.5		17.2	-13.7	140.5	7.4	83.7		.1	246.6
Utah				7.5						7.5
Virginia							3.9			3.9
West Virginia					12.0	-8.0				4.0
Wisconsin			4.5				31.6			36.1
Wyoming			53.2	15.5						68.7
Total	14.2	397.4	754.8	33.9	181.1	28.6	597.7	6.1	.3	2,014.1

TABLE 16.—*Mileage of Federal-aid roads under stage construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Total
Alabama		1.3					54.6	55.9
Arizona		.6						.6
California	2.0			0.6			5.6	8.2
Colorado						9.2		9.2
Delaware							3.9	3.9
Florida					5.4			5.4
Georgia				20.2			10.5	30.7
Idaho			43.5	10.3	3.0			56.8
Indiana							3.5	3.5
Iowa			37.0				100.3	137.3
Minnesota	10.3						44.4	54.7
Mississippi			6.6				24.3	30.9
Missouri	7.5						31.5	39.0
Montana				4.1				4.1
Nebraska		197.4						197.4
Nevada				28.4				28.4
North Carolina	4.2						8.8	13.0
North Dakota	20.1		145.3					165.4
Ohio							6.0	6.0
Oklahoma							6.4	6.4
South Carolina						58.7	62.0	120.7
South Dakota			67.3				6.0	73.3
Texas			3.4		46.7		75.0	125.1
Utah				12.3				12.3
Virginia	7.8				7.4		6.4	21.6
Washington	18.1							18.1
Wisconsin							25.2	25.2
Wyoming			26.2	5.9				32.1
Total	70.0	199.3	329.3	81.8	62.5	67.9	474.4	1,285.2

TABLE 17.—*Mileage of Federal-aid roads approved for stage construction on June 30, 1928, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Bridges	Total
Alabama							12.4		12.4
Arizona						4.2			4.2
Arkansas							6.2		6.2
Colorado				14.5					14.5
Georgia			7.7		31.6		10.8		50.1
Idaho					1.8				1.8
Iowa			22.5				48.9		71.4
Maryland					7.2				7.2
Michigan							6.5		6.5
Minnesota	20.6								20.6
Mississippi								0.6	.6
Missouri							13.7		13.7
Montana			7.8			2.9			10.7
Nebraska		23.2							23.2
Nevada				23.7					23.7
New Mexico								.5	.5
New York							8.6		8.6
North Carolina			4.0				15.5		19.5
North Dakota	1.0		120.7						121.7
Ohio							6.7		6.7
Oklahoma						7.9	7.6		15.5
South Carolina						8.1			8.1
South Dakota			39.2						39.2
Tennessee							94.3		94.3
Texas					54.3		101.7		156.0
Utah			.5	1.0					1.5
Washington							5.0		5.0
Wisconsin							15.7		15.7
Total	21.6	23.2	202.4	39.2	94.9	23.1	353.6	1.1	759.1

TABLE 18.—*Net changes in the types of Federal-aid improvements on the Federal highway system during the fiscal year 1928*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	-6.6	111.5	107.8		20.9		19.9		2.6	256.1
Arizona	.3	-6	15.0	0.1			.4		.4	15.6
Arkansas	11.3		62.9		13.3		2.7		.6	90.8
California	1.7		8.5	-1	.6	55.7	23.0		.9	90.3
Colorado	-5.4	-9.5	26.7				12.0		1.0	24.8
Connecticut				8.7	-1	.6	44.0		2.1	55.3
Delaware					7.0	13.7	14.1	-2.1	.2	32.9
Florida	-8	-5.5	35.0	11.3	6.3	.2	19.5		4.1	70.1
Georgia	34.7	-48.7	6.6	11.7	11.2	.9	109.3		1.9	127.6
Idaho	-43.2	-8.9	16.3	18.2		18.2	.5		1.0	2.1
Illinois					.1		142.2			142.3
Indiana	-3.5		8.7	-15.1	6.3		214.9	6.6	.6	218.5
Iowa	153.3		-19.8				272.0		.5	406.0
Kansas	329.7	74.4	31.7		16.2		110.8	19.5	3.2	585.5
Kentucky	114.9		85.6	-1	28.8		24.3		1.5	255.0
Louisiana	.5		21.2			23.1	12.1		4.6	61.5
Maine			36.0			1.9	27.6		.2	65.7
Maryland	.1			.1	47.5		28.0			75.7
Massachusetts			.4		33.7		13.7		.1	60.5
Michigan	9.9		34.6	.1		-1	130.4		.9	175.8
Minnesota	193.4		-8.8			.1	121.6		.1	306.4
Mississippi	13.3	-4.9	104.8				53.0	.5	5.1	171.8
Missouri	55.1		-18.5	-1.0	-1	-1	126.4		.1	161.9
Montana	8.0		131.9	1.9			.6		1.3	143.7
Nebraska	-168.6	912.3	-42.4			2.9	19.6	1.0	.7	725.5
Nevada	-1.7		61.4	18.6	.1	.1			-7	77.8
New Hampshire				12.4	16.1	.3	5.9		2.4	37.1
New Jersey	2.7		.1				70.4			73.2
New Mexico	-2.2		180.4				.7		1.3	180.2
New York	10.5	4.6	23.8			13.2	332.7		.2	385.0
North Carolina		-48.6					144.7		.7	96.8
North Dakota	-97.4	-4.0	517.5	4.3					1.0	421.4
Ohio	28.1			33.6		.1	127.9	20.7	1.4	259.6
Oklahoma	95.4				22.4	-2.8	102.6			217.6
Oregon	26.0		56.1		-1				.2	82.2
Pennsylvania	14.4				10.6	.1	172.0		.6	197.7
Rhode Island					7.7	-1	10.3		.1	18.0

TABLE 18.—*Net changes in the types of Federal-aid improvements, etc.—Contd.*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Brick	Bridges	Total
South Carolina.....	-18.1	-63.4	-0.2	-----	-----	13.6	70.9	-----	3.0	5.8
South Dakota.....	-235.8	7.6	480.5	-----	-----	-----	1.5	-----	.6	254.4
Tennessee.....	35.4	-----	6.8	-0.1	12.5	5.8	66.4	-----	1.0	127.8
Texas.....	43.4	-----	39.4	-13.7	247.9	14.1	120.9	-0.1	2.7	454.6
Utah.....	.5	-----	76.8	7.5	-----	-----	-----	-----	.5	85.3
Vermont.....	-----	-----	-3.5	4.7	15.5	-----	23.5	-----	.6	40.8
Virginia.....	-3.9	-21.6	-----	3.7	2.9	-----	101.5	-----	1.4	84.0
Washington.....	18.5	-----	22.9	-----	-----	-----	12.2	-----	1.9	55.5
West Virginia.....	66.7	-----	-----	.1	43.3	-1.1	27.1	-----	.8	136.9
Wisconsin.....	-1.1	-6.3	155.8	4.1	-1	-----	181.0	-----	-----	333.4
Wyoming.....	5.2	3.6	98.6	15.5	-----	-----	1.1	-----	.6	124.6
Hawaii.....	-----	-----	-----	-----	13.8	-----	15.8	-----	.1	29.7
Total.....	684.7	892.0	2,360.6	126.5	647.2	159.0	3,130.6	46.1	54.1	8,100.8

TABLE 19.—*Federal-aid apportionment, and amounts paid to the States for the fiscal year 1928, and the unobligated balance of the total apportionment on June 30, 1928*

State	Apportionment fiscal year 1928	Paid to States during the fiscal year 1928	Unobligated balances of total apportionment on June 30, 1928
Alabama.....	\$1,547,220.00	\$2,759,986.85	\$1,645,844.81
Arizona.....	1,056,994.00	422,436.01	2,896,024.65
Arkansas.....	1,277,896.00	796,612.86	1,766,771.75
California.....	2,483,437.00	2,444,944.39	3,363,012.39
Colorado.....	1,376,520.00	1,371,058.74	2,573,202.04
Connecticut.....	472,685.00	415,289.33	566,752.61
Delaware.....	365,625.00	396,176.60	190,680.44
Florida.....	899,451.00	1,261,265.91	1,210,489.75
Georgia.....	1,979,209.00	2,260,205.94	17,567.82
Idaho.....	935,193.00	936,021.88	138,890.41
Illinois.....	3,154,429.00	3,021,486.88	114,597.22
Indiana.....	1,926,772.00	2,767,823.43	267,083.14
Iowa.....	2,044,999.00	3,507,729.88	171,307.77
Kansas.....	2,068,532.00	3,071,637.66	1,284,552.84
Kentucky.....	1,417,947.00	2,214,945.66	529,296.09
Louisiana.....	1,013,308.00	959,664.41	317,573.20
Maine.....	680,794.00	469,834.26	1,380,996.50
Maryland.....	635,119.00	555,946.88	143,816.23
Massachusetts.....	1,089,100.00	676,811.29	2,151,418.10
Michigan.....	2,214,691.00	2,326,490.95	627,344.95
Minnesota.....	2,120,741.00	1,986,635.11	398,471.43
Mississippi.....	1,307,879.00	1,839,908.75	892,222.08
Missouri.....	2,405,175.00	2,658,532.48	1,550,939.55
Montana.....	1,551,499.00	1,778,896.60	4,353,988.31
Nebraska.....	1,585,138.00	2,653,649.87	1,999,143.13
Nevada.....	948,510.00	937,054.96	595,556.89
New Hampshire.....	365,625.00	371,194.25	65,727.25
New Jersey.....	954,611.00	1,319,535.00	253,177.00
New Mexico.....	1,186,763.00	1,417,762.65	894,813.28
New York.....	3,635,217.00	5,061,107.41	3,910,462.81
North Carolina.....	1,713,356.00	1,589,297.53	1,141,531.23
North Dakota.....	1,194,951.00	1,409,404.82	637,992.37
Ohio.....	2,762,209.00	2,183,363.28	2,591,001.85
Oklahoma.....	1,751,891.00	1,618,293.19	387,602.49
Oregon.....	1,182,202.00	658,467.98	1,267,098.47
Pennsylvania.....	3,335,735.00	3,031,621.22	1,850,129.27
Rhode Island.....	365,625.00	318,506.03	576,046.16
South Carolina.....	1,054,988.00	1,259,902.48	64,396.43
South Dakota.....	1,220,064.00	1,167,023.73	514,514.16
Tennessee.....	1,614,766.00	1,157,624.72	254,777.15
Texas.....	4,497,272.00	4,367,659.10	3,975,468.70
Utah.....	846,906.00	1,290,052.52	220,749.79
Vermont.....	365,625.00	694,117.53	25,473.81
Virginia.....	1,442,714.00	1,439,060.08	237,853.61
Washington.....	1,131,532.00	521,599.31	481,843.46
West Virginia.....	793,636.00	1,043,717.00	478,768.16
Wisconsin.....	1,870,455.00	2,959,014.72	1,435,440.82
Wyoming.....	934,369.00	1,106,907.83	167,116.50
Hawaii.....	365,625.00	325,901.59	1,064,241.58
Total.....	73,125,000.00	80,802,232.55	53,643,770.45

NATIONAL-FOREST ROAD CONSTRUCTION

The systems of forest roads in the several States now include a total of 13,911 miles, of which 11,767 miles are in the 12 States of the mountain and Pacific groups and the Territory of Alaska. All appropriations for forest-road construction are being expended upon these systems.

As shown by Table 20, the mileage of class 1 highways, upon which it is planned to expend, until they are completed, approximately 70 per cent of each annual appropriation, is now 1,089 miles, of which 822 miles are in the Western States. These are the more important highways which are necessary sections or extensions of the Federal-aid system wholly within the forest areas. The class 2 highways, which also extend the Federal-aid system, are increased by recent additions to a total of 7,131 miles, of which 6,887 miles are in the West. The class 3 highways, those that serve principally the communities within the forests, now aggregate 5,690 miles, of which 4,057 miles are in the Western States and Alaska.

TABLE 20.—*Classified mileage of forest highway system in several States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:				
Alaska.....			373.8	373.8
Arizona.....	174.0	491.0	243.0	908.0
California.....	321.5	995.6	761.8	2,078.9
Colorado.....		1,228.0	495.0	1,723.0
Idaho.....		738.1	351.1	1,089.2
Montana.....	147.4	657.2	381.0	1,185.6
Nevada.....		376.4	97.0	473.4
New Mexico.....	115.0	211.0	199.0	525.0
Oregon.....	58.0	872.4	409.0	1,339.4
South Dakota.....				
Utah.....	2.0	169.0	63.0	234.0
Washington.....		458.0	299.0	757.0
Wyoming.....	4.7	328.9	239.9	573.5
Total.....	822.6	6,887.6	4,057.6	11,767.8
Eastern:				
Alabama.....			45.0	45.0
Arkansas.....	131.0	51.0	20.0	202.0
Florida.....	3.0	13.0	106.0	122.0
Georgia.....			99.0	99.0
Kentucky.....		6.0	6.0	12.0
Maine.....			11.0	11.0
Michigan.....		13.4	55.0	68.4
Minnesota.....	41.0	38.5	142.0	221.5
Nebraska.....			28.8	28.8
New Hampshire.....				
New Jersey.....	18.3	15.5	62.5	96.3
North Carolina.....		3.0	5.5	8.5
Oklahoma.....	49.0		199.0	248.0
Pennsylvania.....			33.0	33.0
Porto Rico.....	24.5		173.0	197.5
South Carolina.....				
Tennessee.....		6.0	40.0	46.0
Virginia.....		55.0	189.0	244.0
		38.0	269.0	307.0

TABLE 20.—*Classified mileage of forest highway system, etc.—Continued*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Eastern—Contd.				
West Virginia.....		4.0	149.0	153.0
Total.....	266.8	243.4	1,632.8	2,143.0
Grand total.....	1,089.4	7,131.0	5,690.4	13,910.8

As shown by Table 21, 281 miles of forest highways of all classes were completed during the year. Of this total, 259 miles were in the 12 Western States and Alaska, and the remaining 22 miles were in the forests of 3 Eastern States.

The total mileage completed to date, including the results of the last year's work, is 3,775 miles, of which 3,484 miles are in the West and 291 miles in the East.

TABLE 21.—*Mileage of completed forest highway projects by States*

State	Mileage of forest highway projects completed	
	During 1928	Total to June 30, 1928
Western:		
Alaska.....	33.3	184.9
Arizona.....	24.1	261.2
California.....	32.0	284.1
Colorado.....	42.4	308.4
Idaho.....	22.8	462.4
Montana.....	21.0	364.6
Nevada.....	4.1	108.0
New Mexico.....	6.5	170.7
Oregon.....	57.3	573.9
South Dakota.....	3.1	44.6
Utah.....		285.0
Washington.....	7.6	195.9
Wyoming.....	5.3	240.2
Total.....	259.5	3,483.9
Eastern:		
Alabama.....		5.1
Arkansas.....		56.8
Florida.....		64.2
Georgia.....	2.8	21.4
Kentucky.....		
Maine.....		
Michigan.....	8.1	8.1
Minnesota.....		34.6
Nebraska.....		
New Hampshire.....		3.6
New Jersey.....		
North Carolina.....		36.3
Oklahoma.....		
Pennsylvania.....		
Porto Rico.....		
South Carolina.....	10.7	16.0
Tennessee.....		33.5
Virginia.....		11.9
West Virginia.....		
Total.....	21.6	291.5
Grand total.....	281.1	3,775.4

Among the more important roads completed during the year are sections of the Moose Pass, Mill Creek, Tongass, and Glacier highways in Alaska; the Salt River-Pleasant Valley highway and Swift Trail in Arizona; the Emigrant Gap, Truckee-Meyers, and Mendocino Pass highways in California; the mountain crossings through Cumbres, Fremont, Tennessee, and Independence Passes, and a section of the Mount Evans highway in Colorado; the Clark Fork, Ketchum-Clayton, and Salmon-Montana line highways in Idaho; the Columbia Falls-Glacier Park and Roosevelt highways and the Yellowstone Trail in Montana; the Conner's Pass highway in Nevada; the Pleasanton-Box Canyon highway in New Mexico; the Canyon City-Burns, Flora-Enterprise, Klamath Falls-Lakeview, Heppner-Spray, Santiam, and Roosevelt coast highways in Oregon; the Republic-South and Olympic highways in Washington; and the Dayton-Steamboat Rock, and Hoback Canyon highways in Wyoming.

Construction of a number of important bridges was also completed during the year. Among these may be mentioned the Crooked Fork bridge on the Lewis and Clark highway in Idaho; the Coram-Spotted Bear, Hannan Point, and Ear Mountain bridges in Montana; and the Jackson Park bridge in Wyoming.

Additional work, involving surfacing and in some cases reconstruction, was completed on the following projects: The Saxman-Mountain Point section of the Tongass highway, and two sections of the Salmon River project in Alaska; the Flagstaff-Angell project in Arizona; the Yuba Pass project in California; the Tennessee Pass project in Colorado; the McCall-New Meadows, Salmon-Montana line projects, and the Kooskia-Lowell, middle section of the Lewis and Clark highway in Idaho, the latter involving reconstruction; reconstruction and surfacing on the Belt Creek and Sheep Creek sections of the Y. G. B. line in Montana; surfacing of the Scott Creek section of the Alsea River project, the Wapinitia section of the Mount Hood-Wapinitia project, and the Trail-Park Boundary and Flora-Enterprise projects, all in Oregon, and reconstruction and surfacing of the Mount Hood Loop and Oregon Caves projects in the same State; and reconstruction and surfacing of the Junction-Escalante project in Utah, the Excelsior-Shuksan section of the Mount Baker project in Washington, and the Buffalo-Ten Sleep project in Wyoming.

Extensive use has been made during the year of asphaltic fuel-oil treatments of fine crushed gravel and rock roads. This treatment has been used both as a maintenance and a construction measure. It greatly improves the fine crushed rock surfaces, of which so many miles have been built, by eliminating dust and reducing surface wear.

Two general methods are in use, known, respectively, as the surface treatment and mixing methods. The latter gives promise of wider adaptability and more durable results. It consists essentially of the incorporation of a suitable quantity of asphaltic fuel oil, generally 1.5 gallons per square yard, into the upper 3 inches of the crushed-rock surfacing. The cost of a treatment of this kind ranges from \$1,200 to \$1,700 per mile, under efficient management. Surface treatment has also given excellent results where sufficient attention has been given to prior smoothing and compacting of the crushed-stone layer. The quantity of oil required for the surface treatment is only about a half gallon per square yard, but the stone chips that must be applied for the protection of traffic bring the construction cost nearly to that of the mixing treatment, and the maintenance cost is generally higher. Both methods are more than saving their cost by conserving material, and in addition they contribute materially to the comfort and safety of travel and considerably reduce the tractive resistance of the road surface and consequently the expense of operating vehicles.

The survey of the highway needs of sections of Alaska, mentioned in the last annual report, is being continued. As previously stated, one of the principal purposes of the survey is to ascertain what may and should be done by highway construction to develop the mineral deposits, forest resources, water power, and other natural possibilities of southeastern Alaska.

SURVEYS AND CONSTRUCTION IN THE NATIONAL PARKS

In furtherance of the national-park program there was brought to completion during the year, under the bureau's supervision, the improvement of nearly 42 miles of road in five national parks. This work was done under the agreement with the National Park Service by which the bureau has undertaken to survey and supervise the construction of roads in the 1,500-mile, 5-year program of national-park road improvement which has been mapped out. The

roads completed this year bring the total completed under the bureau's supervision to nearly 120 miles; and at the close of the year there were 164 miles additional which were under construction and 322 miles on which surveys were in progress.

The mileage included in the 5-year program in each of the parks, and the mileage completed under the bureau's supervision during the last year and to date, are shown in Table 22.

TABLE 22.—*The 5-year program of national-park road improvement, and the mileage of roads improved under the supervision of the Bureau of Public Roads*

National park	Mileage of the 5-year program	Mileage completed under the supervision of the bureau	
		During the fiscal year 1928	Total to June 30, 1928
Western:			
Crater Lake.....	80.2	1.3	17.5
Glacier.....	141.5	-----	5.5
Mount Rainier.....	112.7	11.8	11.8
Grand Canyon.....	149.4	-----	12.3
Yosemite.....	217.8	13.8	27.4
Sequoia and General Grant.....	115.0	3.8	26.4
Lassen Volcanic.....	45.6	-----	5.8
Yellowstone.....	358.4	-----	-----
Rocky Mountain.....	63.7	-----	1.8
Mesa Verde.....	47.3	-----	-----
Zion.....	23.2	-----	-----
Hawaii.....	81.0	11.2	11.2
Mount McKinley.....	73.5	-----	-----
Total.....	1,509.3	41.9	119.7
Eastern: Lafayette.....	4.5	-----	-----
Grand total.....	1,513.8	41.9	119.7

Of outstanding interest among the projects at present under construction are the Transmountain Highway in Glacier National Park, which is rapidly nearing completion; the Zion-Mount Carmel project in Zion Park, on which the tunneling is an especially interesting feature; the road surfacing projects in Yosemite; the work on the north and south rim roads at the Grand Canyon; and the stage construction betterments of the West Side Highway in Mount Rainier National Park.

In all this work in the national parks special attention is given to the development of aesthetic features of the roads and bridges, and every possible effort is made to avoid scarring the landscape and to preserve the scenic beauties for which the parks are famous.

The fact that the bureau has engineering direction of the work in both the national forests and the national parks has facilitated the solution of problems of correlation between the park roads and those of the surrounding and intervening forests. Several major problems have developed. The two isolated areas of the Grand Canyon Park will have to be connected by a road which must extend through the Kaibab Forest and the House Rock Valley to a crossing of the Colorado at Lees Ferry and thence through the Navajo Indian Reservation on the south side. Some progress has been made in the construction of the Lees Ferry Bridge, but before the route can be developed to full use many miles of road must be built.

Sequoia and General Grant Parks are separated by forest area, through which a road must be constructed as a link in the General's Highway. On the Belton-Glacier forest project there still remains a section of 25 miles to link the two sides of Glacier Park. Much further work is needed, also, on the east and south entrance roads to Yellowstone Park, both within national forests; and provision must be made for the Big Oak Flat and Wawona entrances to Yosemite, both largely within the forest. For Mount Rainier Park a much needed entrance from White River is now under construction as a forest project and an approach to the northwest corner of the park from Fairfax is planned.

The forest and park roads are developing such importance that the question of snow removal must be given careful consideration. During the past winter snow was removed by the State of Colorado on the Tennessee Pass forest project over the Continental Divide. (Elevation 10,400 feet.) The previous winter Berthoud Pass was kept open into February, when the national funds available became exhausted. Other important forest projects which were open during the winter, are the Flagstaff-Angel and Prescott-White Spar project in Arizona; the Canoncito-Pecos project in New Mexico; and the Bear Valley and Swartout projects in California. Snow removal on these projects was made possible by the study given this problem when the locations were made.

SPECIAL ROAD PROJECTS

SURVEY OF FLOOD DAMAGE IN VERMONT AND NEW HAMPSHIRE

Following the unprecedented flood which occurred in Vermont and New

Hampshire in November, 1927, the bureau was requested by the governors of the two States to make a survey of the resulting damage to roads and bridges and estimate the cost, as the basis for a determination of the funds required to replace or repair the damaged highways and bridges.

In compliance with these requests a special force of engineers was organized from the personnel of the bureau, the survey was made, and a report was rendered, in a little more than a month's time, which placed the cost of the damage in Vermont at approximately \$7,400,000, and that in New Hampshire at \$2,700,000.

As a measure of immediate relief in Vermont it was necessary to replace two important bridges over the Winooski River, both of which had been washed away. As the railroad through this river valley was damaged beyond hope of immediate repair it was necessary that both of these bridges be replaced as rapidly as possible in order that the work of rehabilitating the devastated area might be expedited in anticipation of the coming winter.

The responsibility for the construction of one of the two bridges, that at Middlesex, Vt., was accepted by the bureau. A temporary bridge was designed which could be built of materials available in the vicinity; and in 12 days from the arrival of the materials at the site, the bridge was completed at a cost of approximately \$9,000, much of which is salvable.

In connection with the survey of damage, the bureau also made special hydrographic and rainfall studies, assembled eye-witness reports of high-water stages at various points, and accumulated a mass of data and evidence which will be of great value in the future design of bridges and road grades in the area affected.

MOUNT VERNON MEMORIAL HIGHWAY

On May 24, 1928, the President signed the act authorizing and directing the survey, construction, and maintenance, under the supervision of the Secretary of Agriculture, of a memorial highway to connect Mount Vernon, the home of George Washington, with the Arlington Memorial bridge over the Potomac River at Washington. The act authorizes the appropriation of the following sums, to be available until expended: \$500,000 for the fiscal year 1928, \$2,000,000 for the fiscal year 1929, and \$1,000,000 for each of the fiscal years 1930 and 1931. It is the purpose to complete the highway by 1932 in

order that it may be officially opened and dedicated as an incident of the celebration of the bicentennial of the birth of Washington in that year.

Prior to the passage of the act the bureau had made reconnaissance surveys of two possible locations at the request of the Committee on Roads of the House of Representatives and had furnished the committee with an estimate of the cost of constructing the road on a suitable location.

Since the passage of the act the Secretary of Agriculture has delegated the duty of surveying and supervising the construction of the highway to this bureau; and detailed surveys with the object to fixing the final location were begun on June 15, 1928. Work on these surveys will be prosecuted with all possible vigor, and it is hoped that a final decision on the location may be possible in time to let contracts and start the grading during the fall of 1928 in order to allow as much time as possible for the consolidation of the fills before surfacing is applied.

HIGHWAY RESEARCH

THE CLEVELAND HIGHWAY PLANNING SURVEY

The outstanding economic research project of the year was the survey of traffic and study of the causes of traffic congestion in the metropolitan region surrounding the city of Cleveland, Ohio. This project, initiated at the request of the board of county commissioners of Cuyahoga County, Ohio, in September, 1927, and conducted in cooperation with that body and with the assistance of officials of other counties and numerous cities, villages, and townships in the metropolitan region, was completed during the fiscal year.

As a result of the survey a plan for the future development of the existing roads of the area and the construction of new arterial, by-pass, and relief highways has been prepared by the bureau and enthusiastically adopted by the authorities of all jurisdictions concerned, and active preparations are now being made to construct the planned improvements.

As a basis for the plan, a great mass of data was obtained concerning the average and maximum density of traffic on all important highways in the area; the origin and destination of the traffic; the most direct routes from origin to destination of the large movements, and the causes of habitual departure from such routes where it was

found that traffic was not following the direct route; the habitual speed of traffic and conditions influencing speed and causing congestion, such as grade crossings, street-car tracks and loading platforms, traffic lights, the convergence of heavily traveled highways, etc.; the width of pavement required to accommodate various densities of traffic; the possibility of establishing new routes which will relieve congestion on present routes and provide more direct communication between various areas; and other facts of similar fundamental importance.

This mass of data was carefully analyzed, and, after a detailed study and appraisal of the condition and availability of existing pavements, a plan of new construction, resurfacing, and surface widening was drawn up which utilizes to the greatest possible degree the improvements previously made in the area. Because of the thoroughness of the study there is high confidence that the plan developed will provide a satisfactory solution of the intricate traffic problems of this important area and will do so with economy.

Not the least of the accomplishments in connection with this survey and plan, of which the bureau is especially proud, is the success which attended its efforts to bring together and harmonize the interests of the many more or less independent jurisdictions involved, without which no consistent highway development in the area would be possible. The beneficial results of this cooperation which will shortly be manifested in concrete form may well serve as an object lesson to other communities similarly constituted and beset by similar problems.

PHYSICAL RESEARCHES

The physical researches of the bureau relate to the character and use of highway materials and to the behavior of highway structures. The purpose of this work is to develop scientific facts which may serve as a basis for the establishment of sound engineering practices and which will result in effective and economical highway construction. The investigations include detailed studies to determine the characteristics of the various materials, the comparative values of different materials which may be used for the same purpose and the best methods of using them in construction, the forces which tend to destroy highways and the most effective means of resisting these destructive forces, and the manner in

which the various materials and combinations of materials fulfill their purpose.

The value of this work can scarcely be overestimated. This is due to the fact that the results are multiplied in their application year after year to a vast mileage of roads still to be built or rebuilt. The comparatively small saving made possible by the improvement of just one material or item of construction is multiplied time after time by repeated use of the improvement on each mile of road in which the particular material or item is involved. In time there is returned to the public a saving out of all proportion to the comparatively small expense of the research which made it possible.

The following description summarizes briefly the more important of the physical researches which have been current during the past year.

SUBGRADE INVESTIGATIONS

It is the present practice in road construction to build pavements without regard to variable subgrade conditions. A pavement which is heavy enough for the good subgrades may fail in those portions where the subgrade is bad. If it is heavy enough for the bad subgrades it is unnecessarily heavy, and therefore unduly expensive, for the portions of the road where the subgrade is good. It has been estimated that in certain localities the difference in cost between a concrete pavement suitable for a good subgrade and one suitable for a poor subgrade may amount to as much as \$3,000 per mile, or from 10 to 15 per cent of the total cost. Considering the great mileage of highways which must be paved, it can be appreciated that the savings which will result from an accurate knowledge of subgrades may be enormous.

For these reasons the subgrade investigations which are now under way are considered as among the most important of the bureau's physical researches. They are perhaps also the most difficult of the investigations with which the bureau is at present concerned, for they constitute a fundamental research in a problem of extreme complexity.

Laboratory and field investigations are being carried on simultaneously to develop the required information. In the laboratory a study is being made of various tests which will serve to identify and classify soils for the purposes of the highway engineer. In this work advantage is being taken

of the extensive work of the United States Bureau of Chemistry and Soils in the classification of soils for agricultural purposes. In the field, surveys of roads and pavements are being made in different parts of the country, where the conditions are most favorable for such work, to determine the influence of soil characteristics on pavement behavior and to observe the efficiency of the various corrective measures which are being used to improve poor subgrades. A laboratory and field investigation of the failure of roads due to frost action is also in progress.

The subgrade investigation requires the concerted efforts of the physicist, the soil scientist, and the highway engineer. Certain portions of the work are conducted independently by the Bureau of Public Roads, while others are conducted with the cooperation of the Bureau of Chemistry and Soils, the Massachusetts Institute of Technology, the Ohio State University, and the University of South Carolina.

In research of this character rapid progress is not to be expected since the procedure can not be outlined in advance but must be developed step by step and with extreme care, using as a basis the information made available by the preceding phases of the work. However, definite progress is being made. Already it has been possible to develop a soil classification, useful for highway purposes, and to establish, within broad limits, practices in design and construction which promise success when applied to the building of roads involving possible combinations of the various types of road surface with the various classes of soils.

Somewhat related to the problems connected with subgrades is the problem of landslides. Landslides are responsible not only for the expenditure of enormous sums annually for extra highway maintenance, but they are a menace to the safety of the traveler and seriously interfere with the flow of highway traffic. In general, it may be said that the present methods of road construction and maintenance aim only at the correction of the damage due to slides after they have occurred and make little attempt to control the causes which produce them. In many instances such methods promise nothing more than an almost indefinite continuation of the existing trouble.

The bureau has made a survey of slide conditions in Ohio, West Virginia, and Pennsylvania, as a result of which it is believed that the cooperation of

geologist and engineer can do much to improve conditions. Even a partial alleviation of present troubles is of sufficient importance to justify a comprehensive study of the situation. Suitable drainage is indicated as the necessary corrective measure which will be effective in a large majority of cases.

LOW-COST ROAD INVESTIGATIONS

Outstanding in the research developments of the past year have been the results of the study of light oil treatments of crushed rock and gravel roads in the Western States. Thousands of miles of such roads have been constructed and have proved adequate for the traffic. However, they have been found to have two serious defects. They are extremely dusty in dry weather, in some cases to such an extent as to seriously menace the safety of traffic, and they are worn down rapidly by the wheels of vehicles. In some cases from 1 to 1½ inches of surfacing material may be lost in a year. The yearly cost of replacing this lost material may easily amount to as much as \$1,000 per mile. To eliminate these objectionable features, methods of treatment with light asphaltic oils have been developed and used in Oregon and California.

With the cooperation of the California Highway Commission, the bureau has made an extensive study of this type of improvement. A report describing the methods of treatment and the essential principles necessary for successful construction has been published during the year and distributed to highway officials throughout the country. This report has proved to be of immediate value, for already a number of the States are using the new methods in construction and maintenance work.

In South Carolina the cooperation with the State highway department, in the treatment of sand-clay and topsoil roads with tars and asphalts, has been continued, and a valuable report describing the earlier experiments has been issued. The objectionable features of untreated sand-clay and topsoil roads are similar, in some respects, to those of the crushed-rock and gravel roads of the West, in that they wear rapidly and are extremely dusty in dry weather. In addition to these defects, many of them become muddy during periods of wet weather. The experiments have been so successful in developing satisfactory low-cost surface

treatments for roads of this type, resulting in greatly improved all-weather service, that considerable mileages of highways have already been improved by the new methods. Sand-clay and topsoil are used extensively in the Southern States for the construction of light-traffic roads, since the materials are readily available in many sections and relatively inexpensive. This investigation has produced results of great value to that section of the country.

In the coastal plain region of the South Atlantic States there are large areas where the use of the local materials produces unstable and extremely unsatisfactory soil-type roads and where the better classes of materials are unduly expensive on account of distance from the source of supply. The cooperative experimental work in South Carolina has been extended to this area for the purpose of developing "mixed-in-place" treatments which will stabilize the soil-type roads which now exist and thus increase their service value. The experimental sections which have been constructed are not yet of sufficient age to permit of definite statements as to their value but the present indications are that the "mixed-in-place" type of construction may be used with the materials locally available to produce economical and serviceable light-traffic roads.

VIRGINIA DEMONSTRATION ROAD

What is known as the Virginia demonstration road is a research project of more than usual interest and one which it is believed will eventually rank in importance with the Bates Road (Illinois) and Pittsburg (California) tests. Unlike the previous test roads, the demonstration road was not built primarily for testing purposes and does not constitute a test of road design or of surfacing materials. It is a concrete-paved highway, built for and carrying the regular highway traffic. The investigations which are being made are studies of the effect of variable subgrade conditions and various construction practices, such as methods of placing, finishing, and curing concrete and the use of joints of different types.

The road is located in northern Virginia between Fairfax and Warrenton. It is a Federal-aid project, and the experimental features are handled cooperatively by the bureau and the Virginia Highway Commission. The test sections, which are 60 in number and

have a total length of approximately 12 miles, were built during the construction seasons of 1926 and 1927. Observations covering a period of several years will be necessary to determine the influence of the variables which are included in the study. This demonstration is claiming the attention of highway officials throughout the country and the knowledge which will be gained will undoubtedly exert a major influence on future highway construction. A progress report descriptive of the project has been published.

CONNECTICUT AVENUE EXPERIMENTAL ROAD

The Connecticut Avenue experimental road, extending from Chevy Chase Circle to Chevy Chase Lake in Montgomery County, Md., was constructed by the bureau during the years 1911, 1912, and 1913. The experiment involved the construction and subsequent observation of numerous types of pavement, including bituminous penetration macadams, surface-treated macadams, Portland cement concrete pavements, and asphaltic concrete and brick wearing surfaces on Portland cement concrete bases. During the ensuing 15 to 17 years the road has been subjected to a very heavy traffic. Throughout this period it has been maintained by the bureau, and the maintenance costs, together with the observed behavior of each section, have been carefully recorded.

The experiment is unique in that it has made available accurate maintenance costs, extending over a considerable period of time, for a number of the more important types of pavement construction. In addition to this it has yielded much valuable information regarding the effect of various design and construction practices on the subsequent behavior of these types of pavements. During the year there has been published an instructive report describing in detail the present condition of the experimental sections and the yearly costs of preserving their surfaces in serviceable condition.

MOTOR-TRUCK IMPACT INVESTIGATIONS

The impact forces delivered to a pavement by the hammerlike blows of the wheels of a moving truck may be enormous as compared with the weight of the same wheels at rest. It is essential to have a knowledge of these impact forces and the variables

which determine their magnitude. This is necessary for two reasons: (1) In order that pavements may be built strong enough so that they will not fail under traffic conditions, and (2) in order that reasonable regulations may be developed to govern the operation of vehicles. The interrelationship between the highway and the vehicle is such that highway design and vehicle regulation must be adjusted to each other so as to result in maximum economy. The economic development of highway transportation must be encouraged, and at the same time the enormous investment in highways must be safeguarded.

The Bureau of Public Roads has been a leader in the study of the factors in motor-vehicle operation which influence the destructive effect on the highway. Past work in this field has served to produce the complicated instruments necessary for the measurement of the instantaneous blows of truck wheels and to develop the basic data which may now be utilized in more extended studies which will yield results of the greatest practical usefulness. The work is being continued with the cooperation, as in the past, of the Society of Automotive Engineers, representing the interests of the motor-vehicle manufacturers, and the Rubber Association of America, representing the manufacturers of rubber tires.

One of the current motor-truck impact investigations is to determine if the use of special types of resilient or cushion wheels has any tendency to decrease the destructive effect of the impact forces. This study was prompted by the possibility that improvements in wheel design may be fully as important in reducing impact forces as are improvements in tire design.

Another investigation, which was made during the past year and concerning which a report has been issued, was to answer the question which has been raised repeatedly during the past as to whether or not certain types of pavements, notably asphaltic surfaces on concrete bases, possess cushioning or shock-absorbing properties, by virtue of which the pavement base is protected from the full effect of the impact forces. This information is required if competing types of pavements are to be designed on a comparable strength basis. As a result of these tests it was concluded that there is no appreciable difference in the cushioning properties of the rigid-type pavements, irrespective of the type of wearing surface which may be used.

HIGHWAY-BRIDGE INVESTIGATIONS

The rapid development of the present highway program has resulted in an immediate need for information relative to so many phases of the work that many investigations, important in themselves but less urgently needed, have of necessity been deferred. At present the fundamentals of bridge design are much more thoroughly understood than are those of many other phases of highway construction and for this reason it has been necessary, temporarily, to relegate to the background desirable researches relating to the design of drainage structures. In spite of this necessity the bureau has engaged in some rather important bridge investigations, the more notable of the recent ones being the Delaware River bridge tests and the North Carolina bridge tests.

The Delaware River bridge investigation, which was completed prior to the beginning of this fiscal year, was described in the last annual report. A report, giving the results of the investigation, has been published during the year.

In the previous report mention was made of the proposed loading tests on a large concrete arch bridge of modern construction. The bridge in question, which was built in 1922 as a Federal-aid project, was located on the Pee Dee River near Albemarle, N. C. It consisted of three concrete, open-spandrel, arch spans of about 150 feet each and 14 concrete, deck-girder, approach spans of about 40 feet each, the total length of the structure being approximately 1,070 feet. A dam, which was built several miles downstream for power-development purposes, made necessary the destruction of the bridge since it would have been completely submerged by the impounded water. A new bridge was constructed at a higher level to replace it and the older structure was thus made available for test in the interval prior to the completion of the dam.

Advantage was taken of this unusual opportunity and a program of loading tests has been conducted cooperatively by the Bureau of Public Roads and the North Carolina State Highway Commission with the advice and assistance of a committee of distinguished representatives of a number of the national engineering organizations.

The loading tests were made with two large timber tanks filled with water, the loaded weight of each tank being approximately 160 tons. Stress

measurements were made under various conditions of loading for comparison with the stresses computed by theoretical methods of analysis. Tests of this character could ordinarily be made only at enormous expense for the test loads were carried to a point which resulted in serious damage to the structure. Upon completion of the loading tests the bridge was destroyed, under the direction of the War Department, by demolition tests with explosives.

The accepted methods of concrete arch design are based on theory. Experience has shown that these methods result in the construction of bridges of ample strength for the loads intended but the opportunity has never before been given to test the theory by the experimental loading of a large arch bridge where damage to the structure was of no consequence. A report of this work will be published during the next year.

CONCRETE INVESTIGATIONS

The physical variations which affect the strength and integrity of concrete and the effects of certain external forces on concrete structures are, as yet, most imperfectly understood. The bureau, in common with other research agencies, is carrying on extensive investigations in many phases of this subject, which is one of considerable importance in bridge and pavement construction.

Some of the factors which affect the quality of concrete are quality of cement; type, quality and gradation of fine and coarse aggregates; proportions in which the constituent materials are combined; admixtures of other materials which may be added for any one of several purposes; and methods of curing. On the quality of the concrete is dependent its ability to resist destruction. It must withstand the stresses produced by external loads, such as the wheel loads of vehicles, and the internal forces resulting from changes in length due to variations in temperature and moisture. In pavements it must resist the abrasive action of the wheels of vehicles; when exposed to the weather it must resist frost and other weathering action; and in certain conditions of exposure it must resist the destructive effects of salt water or alkali. With all of these problems the researches of the bureau have been concerned.

Among the more important concrete researches now in progress are the studies of concrete-curing methods,

tests to determine the effect of variations in type and gradation of coarse aggregates on the strength of concrete, the effect of type of aggregate on the resistance of concrete to frost action, and investigations of methods for protecting concrete from the effects of sulphate waters.

DEVELOPMENT OF SPECIAL APPARATUS

In connection with many of the investigations of the bureau there has arisen the necessity for developing and constructing scientific apparatus and equipment for special purposes. Some notable achievements have been made in this field. Among the more important of the recent inventions are the relative roughness indicator for measuring the roughness of road surfaces and the traffic flow recorder for use in connection with traffic surveys.

The knowledge that smoothness of road surface is an important consideration in pavement construction has created a demand for a simple and convenient instrument which will give a relative measure of this quality. To meet this demand the bureau developed the relative roughness indicator or "roughometer," a comparatively simple device which may be attached to any automobile. The instrument is based on the principle that the amount of spring deflection of an automobile bears a direct relation to the degree of road roughness. The record gives the total amount of spring compression in inches for any given distance and a comparison of records obtained on different roads gives a relative measure of their roughness. A number of the instruments are being used by the various State highway departments and one is in use by the Swedish Institute of Roads.

The traffic-flow recorder is a device designed to measure and record the speed of a vehicle at any instant and simultaneously to record the time and distance from any fixed point at the beginning of a trip. It consists of a clock, an odometer, and a speedometer, all so mounted in a box within the field of a camera that they can be photographed simultaneously. The instrument is used to measure and record the variable speed of highway traffic and the simultaneous records of time, speed, and distance which can be made at any instant furnish the data necessary for studies of the flow of traffic as affected by obstructions, congestion, or other variables. It has been used successfully in the cooperative highway

planning survey in the Cleveland metropolitan region.

STUDIES OF HIGHWAY PRODUCTION ECONOMICS

In this field the work of the past year which is worthy of special mention has dealt with three problems, as follows: (1) The possibility of reducing the cost of pavement concrete, without detriment to its strength and uniformity, by reducing the length of the mixing period; (2) the possibility of reducing costs and improving the surface smoothness of asphaltic pavements by the use of mechanical finishing methods; and (3) the economies possible in the use of power shovels in highway grading.

CONCRETE MIXING TIME STUDIES

To reduce costs, waste must be eliminated wherever possible, and ways and means must be sought to utilize equipment to its most economic capacity to develop the rate of production to its economic optimum without impairing the quality of the finished product. Since most road-construction work involves one or more operations which are repeated over and over again many times each hour, one of the most important factors in determining the cost of performing such work is the length of time required for each of these repetitive operations. This is especially true in those lines of work in which the type of the equipment and construction methods so fix the daily cost of operation that it is very largely independent of the rate of production. Concrete road construction is a good example of this class of work. The daily cost of operation for any particular modern outfit varies but little whether the rate of production is high or low. Furthermore, the maximum possible rate of production is definitely fixed by the time required to put the batch through the mixer. Thus, if $1\frac{1}{2}$ minutes are required to put a batch through the mixer, then 40 batches per hour is the maximum possible rate of production, no matter how perfectly all subsidiary operations are synchronized. But if the time required for putting a batch through the mixer can be reduced to one minute then the possible rate of production rises to 60 batches per hour, or an increase of 50 per cent.

Since the time required to put a batch through the mixer is determined so largely by the length of time the

materials must be held in the drum for mixing, the question at once arises as to how long a mixing time is really necessary with our modern pavers in order to produce a satisfactory concrete. As little or no definite data were available to answer this very important economic question, the study was made sufficiently extensive to cover the normal range of actual field conditions as to equipment, materials, and any regional variations in methods or practices. These studies extended over a period of more than two years, covered 24 jobs in seven States, and involved the making and testing of more than 2,000 cylinders, as well as many beams and cores.

The result of these studies, which has just been published, shows conclusively that with our modern pavers the customary mixing time can safely be reduced to one minute without detriment to the strength of the finished roadway.

STUDIES OF MECHANICAL FINISHING METHODS FOR BITUMINOUS PAVEMENTS

In the construction of bituminous pavements one of the time and labor consuming operations is that of so spreading the hot material as to secure a smooth and uniformly compacted road surface. While the bureau's studies of mechanical methods for performing this operation are as yet far from complete, they have progressed sufficiently to show that the ordinary mechanical finishing machine so generally used in concrete road construction work can readily be equally adapted to bituminous road construction. In a number of cases so far studied, not only has the use of the mechanical finisher produced a smoother riding surface, but it has also permitted the handling of more material at a lower labor cost. Thus, on a job in Hughes County, Okla., the spreading and raking when performed by hand methods placed a definite limit to the amount of rock asphalt surfacing which could be placed per hour. After the installation of a mechanical finishing machine the average rate of surfacing placed per hour of operation was increased from 218 square yards to 334, which was the limiting output of the heating plant. Other items of interest noted on this project were that with hand raking the labor cost of the entire road crew was \$12.50 per hour, but after the finisher was installed the labor cost was reduced to \$8.05 per hour, al-

though more than 50 per cent more material was being placed, and that with the mechanical finisher the material was being spread as readily when it reached the road at a temperature of 300° to 325° F. as was possible by hand methods when the temperature of the material was 375°. While the above job probably presented unusually favorable conditions for the use of the mechanical finisher, all the bureau's studies to date indicate that, even under the most unfavorable conditions, a proper use of the mechanical finisher will produce a smoother and more uniform riding surface and also handle a larger yardage of material than can ordinarily be done by present methods of hand raking.

EFFICIENCY IN POWER-SHOVEL OPERATIONS

The more important factors which affect the rate of production and unit costs in highway grading work with the power shovel have been described during the past year in the bureau's magazine, *Public Roads*. These studies are the result of four years of extensive field work and the analysis of more than a hundred grading projects.

The cost of grading is perhaps the largest single item in the highway bill of the country and a great deal of this grading is done with the power shovel. For this reason alone the question of whether or not the efficiency with which these important tools are operated and whether or not their present rates of operating efficiency can be increased is of great economic importance.

These studies have brought out very clearly how the operation of the power shovel involves not only a large number of repetitive operations but also several independent operations, all of which must be properly synchronized. First, the dipper must be loaded, swung, and spotted over the hauling unit, the load dumped, and the dipper returned for another load. From time to time the shovel must be moved forward or maneuvered so as to keep it within digging reach of the material in which it is working. But, except when casting is possible, a shovel can dig only when and as hauling units are in place to receive the excavated material. Every interruption in the steady supply of hauling units in proper place at the shovel is therefore inevitably registered as a reduction in production. Furthermore, the hauling equipment can handle material no faster than it can be received at the dump. Consequently, all these opera-

tions must not only be performed at the proper rate of speed but must also be properly synchronized in order to attain any reasonable degree of efficiency, because as these operations are repeated over and over again throughout the day, a few seconds or even fractions of seconds regularly lost in any part of these operations inevitably results in a loss in productivity which soon amounts to large proportions.

In practically all highway grading work with the power shovel the length of haul is not constant, but fluctuates, often with great rapidity and between very wide limits. Since actual job conditions usually make it impossible for the contractor to vary the number of his hauling units in accordance with the fluctuations in the length of the haul, one of the most difficult questions facing the highway grading contractor who operates a power shovel is, "What kind and how many hauling units should be placed on a particular job in order to complete the work at the lowest possible cost?" These studies have developed a practical method, which is given in considerable detail, by means of which the number of hauling units of any given kind which should be placed on a given job can be determined with reasonable accuracy.

IRRIGATION INVESTIGATIONS

DUTY OF WATER STUDIES

During the year there has been published the second of a series of bulletins on irrigation requirements of arid and semiarid lands. It covers the Missouri and Arkansas River Basins. A manuscript for the third bulletin of the series, dealing with the Southwest, has been prepared, and data now are being compiled for the fourth of the series, on the Northwest.

Because the natural water supply of southern California is exceedingly limited and the demands for water are great and constantly increasing, the economic use of water in that locality is being studied intensively. In co-operation with the State department of public works, experiments are being carried on in different sections of that part of the State to determine the least amount of water that may be applied in irrigation for economic crop production. A report on the San Diego area is now being prepared. Similar studies are being made in Orange, Riverside, and San Bernardino Counties. A special cooperative investigation has been started to determine the penetra-

tion and storage of rain falling upon the valley floor of the Santa Ana River area in Orange, Riverside, and San Bernardino Counties. In cooperation with the city of Los Angeles, studies have been made in San Fernando Valley, where approximately 60,000 acres are irrigated from the Los Angeles aqueduct. Cloudbursts have several times disabled the main aqueduct and forced restriction of the use of irrigation water, and at such periods the problem of allotting water fairly for each kind of crop and deciding their priority is a perplexing one. The investigation is for the purpose of determining the amount of water required for profitable crop production, and a more efficient use; the field work consists of (1) general duty of water studies, based on the measured amount of water applied to each farm in the valley, and (2) consumptive-use studies, based on soil-moisture investigations.

LOSS OF WATER BY EVAPORATION

During the season of 1927-28, the study of the evaporation from tanks of different types and sizes was continued. Three standard types were used, and for comparison observations were made on a copper-lined concrete reservoir 84.8 feet in diameter. All the tanks were exposed under the same meteorological conditions. The results show that the small tanks all lose water at a higher rate than the large reservoir.

Observations were made to determine the effect of altitude on evaporation from a free water surface, and some special tests were carried on to find the effect of temperature on the equipment used in the evaporation experiments under controlled conditions in the laboratory. The latter experiments show that although temperature does affect the results, the magnitude of the effect is not as great as previously thought and that the effect may be eliminated by measuring the evaporation between points of equal temperature.

Observations were also made on the evaporation from a heated water surface under outside conditions in the winter, and an attempt was made to measure the evaporation from ice. During the experiments on evaporation from a heated water surface, although the air temperature dropped below freezing on several occasions, the evaporation remained about equal to the summer rate. The experiments on the evaporation from ice were not

successful because the water melting from the ice during warm periods spilled from the evaporation pan, but some tests made in the laboratory without wind show that there is an appreciable evaporation from ice.

Data have been obtained relative to evaporation from moist soils, using loam, heavy adobe, and fine river sand containing some silt. When the depths of water table were 1, 6, and 12 inches, evaporation from the sand was about equal to that from a free water surface; the loam showed a decrease at the greatest depth, and the adobe at both lower depths.

PUMPING FOR IRRIGATION

A manuscript on pumping for irrigation has been completed which discusses the methods and practices followed in certain representative districts in the western United States, the economic problems which limit the profitable utilization of the pump in irrigation practice, a procedure for determining whether a pumping venture may succeed, types of standard equipment and their uses, a study of plant efficiency, and power and power problems.

IRRIGATION NEEDS AND POSSIBILITIES OF THE GREAT PLAINS

The studies of this subject lead to the belief that the most important industry of the region will always be the production of animal products, and that this industry can best be practiced by a combination of the usual types of plains farming supplemented by irrigation for growing special crops that are found peculiarly suited to certain localities, such as celery near Kearney, Nebr.; cantaloupes near Rocky Ford, Colo.; and spinach near Austin, Tex. Intensive farming results in the development of towns and communities that afford marketing centers, and educational and entertainment facilities not available in more sparsely settled areas.

DESIGN, INVENTION, AND TESTING OF APPARATUS

The improved Venturi flume, developed by the division of agricultural engineering for measuring flow in open ditches with a minimum loss of head, now is widely used in the western irrigated States and to some extent in foreign lands. In cooperation with several irrigation companies, a 20-foot flume of this type was built and tested in the Arkansas Valley, with very satisfactory results, the ca-

capacity exceeding 1,000 second-feet. Plans for a structure with 35-foot throat and a capacity of 1,800 second-feet are now in preparation.

CONTROL OF GRAVEL AND SILT IN IRRIGATION CHANNELS AND RESERVOIRS

In cooperation with the Utah Agricultural Experiment Station, studies of stream action above and below gravel and flood barriers were continued at nine locations. One additional stream, Summit Creek at Santaquin, has been placed under control. The newly completed barrier has eliminated the trouble completely, permitting a complete utilization of the water. A series of checks and equalizers has been built at Garfield in Salt Lake County, Utah, above the plant of the American Smelting & Refining Co., which sustained a loss on June 10, 1927, of over \$150,000 through a heavy summer flood which carried boulders weighing tons through the plant and left a path of destruction in its wake. These control works cost a little under \$175,000. Five smaller floods occurred during the course of construction which added considerably to the store of information already available, and tested sections of the work already completed or under way. Another barrier is in process of completion at Mount Pleasant, Utah, which will be finished during 1928. The latter structure offers protection to the town and adjacent farm lands, and if successful, will save the irrigation headworks from washing out each year in midseason.

The study of silt control on the Colorado River was completed in 1926, and a bulletin entitled "Silt in the Colorado River and Its Relation to Irrigation" was issued in 1928. A similar study of streams in Texas, in cooperation with the State board of water engineers, is being continued.

FLOW OF WATER IN DITCHES, PIPES, AND OTHER CONDUITS

A manuscript on the flow of water in metal pipes is nearly completed, and will be submitted before the close of the present fiscal year. Studies are also being carried on concerning flow of water in flumes.

CUSTOMS, REGULATIONS, AND LAWS RELATING TO IRRIGATION

A bulletin has been issued during the fiscal year, dealing with methods adopted by irrigation organizations for the delivery of water and canal management, and a report upon financial

settlements of defaulting irrigation enterprises has been prepared. In cooperation with State institutions, irrigation districts that were confronted with unusual financial problems have been studied and reports were made on the Warm Springs, Ochoco and Grants Pass projects in Oregon, and the San Pedro irrigation district in Arizona.

RECLAMATION OF ALKALI LAND

One of the foremost problems encountered in irrigated agriculture is the reclamation of alkali lands. Owing principally to neglect in promptly draining water-logged lands, harmful salts have accumulated in the surface soils of large land areas, which render them useless for agriculture until the salts are removed. Though much land of this character has been reclaimed, failure to do so is common under the condition known as "black alkali." Under cooperative agreement with the agricultural experiment station of Idaho an exhaustive study of the problem has been carried on since 1926 on a 50-acre tract of extremely adverse alkali land. The condition of black alkali soil which is responsible for the slowness in responding to reclamation, has been traced to the mechanical rather than the chemical condition of the soil. The application of chemicals to make the salts more readily soluble, and efforts to make the soil more permeable by blasting, subsoiling, and alternately wetting and drying it, have so far failed to improve the condition. Perhaps economical reclamation of this land will depend upon the production of crops that will compensate the landowner for his efforts, while their root action and chemical action and the leaching effect of irrigation water bring about permanent reclamation. Progress has been made along this line, but the results need verification.

DRAINAGE RUN-OFF FROM IRRIGATED LANDS

Data have been collected from nearly 100 drainage projects, having an aggregate area of about 1,000,000 acres with 2,500 miles of drains, in 13 Western States, showing the maximum discharge per unit of area drained, the maximum discharge per unit of length of drain, the total annual discharge by months, the relation of discharge to irrigation water applied, and as far as possible the factors which influence the rate of discharge. This information will be of value and assistance to drainage-designing engineers and to irrigation

projects which propose to develop part of their supply from drainage works.

IRRIGATION IN HUMID REGIONS

Overhead irrigation for market-garden crops has proven profitable in many localities in the Northeastern States, but this method is too expensive for general farm crops in that region. A study of the practicability of surface irrigation has been started in cooperation with the training school at Vineland, N. J. Measurements of maximum and minimum flow in the creek have been made, and construction of the dam has been begun by the training school. Observations will be made of the frequency and amounts of irrigation, and of the effect upon crop production, comparing the results with crops growing on unirrigated land.

DRAINAGE INVESTIGATIONS

STUDIES OF RUN-OFF AND DITCH CAPACITIES

Determination of the rates at which water collects in the drainage courses during or following storm periods and the sizes of channels necessary to remove the water are fundamental in designing systems of land-drainage improvements. Therefore data have been collected for many years to show the quantities of water flowing from a considerable number of drainage areas, and a great many experiments have been made on the carrying capacities of drainage ditches and natural water courses. The drainage areas vary greatly in size, shape, topography, soil, and surface covering. Such studies have been made in Mississippi, Arkansas, Missouri, Iowa, and Illinois, and in the past year have been begun in northern Indiana. Continuous records have been kept of the flow from each area and of the rainfall over the area, and careful descriptions have been prepared of the various physical features of the areas.

In selected courses of the ditches and natural channels there were made, besides the gaugings of discharge, measurements of the slope of the water surface and of the size, shape, and uniformity of the stream. From these data, values of the empirical coefficients in the Chezy and Kutter formulas have been computed. The experiments include large and small ditches and natural channels, and determinations of flow through standing timber and through sections from which the timber had been cleared in the flood-

ways in Cape Girardeau County, Mo., and Poinsett County, Ark. These data and values, with illustrated descriptions of the channels, have been prepared for publication as a bulletin on the flow of the water in drainage channels.

GROUND-WATER STUDIES

One of the perplexing conditions in studying the drainage of farm lands is the uncertainty in applying the results of investigations in one type of soil to the control of ground water in another type. In too many instances, methods of drainage found effective in one locality have not been satisfactory when used in other localities, for soils that seemingly were similar. The division of agricultural engineering, therefore, has undertaken studies to develop, if possible, a method of determining from fairly simple physical tests how readily any particular soil will respond to underdrainage, and a method of indexing soils according to their drainage characteristics. A great number of soil samples have been collected for analysis from fields where ground-water studies have been made and the drainage requirements are known.

SOIL EROSION INVESTIGATIONS

In cooperation with the agricultural experiment station at Raleigh, N. C., the experiments to determine the rates at which soil is washed from cultivated hillsides by surface water have been continued. Experimental plots on one of the typical soil types have been so arranged that the amounts of water flowing from each plot and the amounts of soil washed off are measured. The plots are cultivated to different crops, in order that not only may the rate of erosion be related to the rainfall and the run-off, but also the effect of different cultural methods retarding or increasing erosion may be studied.

DRAINAGE MATERIALS

Studies relative to the quality of clay drain tile for sale in Minnesota are being made in cooperation with the University of Minnesota, and the Minnesota department of drainage and waters. Samples of tile from all the operating clay-tile factories in Minnesota, and from a few in Iowa, were tested for strength, for absorption, and for resistance to freezing and thawing, according to the standards for drain tile adopted by the American Society for Testing Materials. The correlation

of the results of these experiments makes it possible to determine the resistance to freezing and thawing of any shipment from any of the factories within three days, from tests of strength and absorption only, whereas the freezing and thawing test requires six weeks or more.

In connection with the studies on concrete drain tile, also in cooperation with the same Minnesota agencies, tests have been made on different brands of Portland cement to determine their resistance to the action of water containing sodium sulphate. The results of the tests indicate that more-resistant cements will withstand the action of the salt for three to five times the life of the less-resistant kinds. It appears that in waters having small amounts of sulphates the resistant cements probably will be durable, while the others may fail in a few years. Studies have been undertaken to develop an accelerated test for determining the resistance of Portland cement to action of sulphate waters.

The testing of concrete and mortar specimens in peat soils is being continued. Action of soil chemicals on some of the specimens has been noted, but the tests have not advanced far enough to warrant drawing conclusions.

OPERATION AND MAINTENANCE OF PUMPING PLANTS

Where drainage requires that the water be discharged from the area by pumping, the improvement is much more than ordinarily expensive. Along the Illinois River and along the Mississippi between St. Louis and Savanna, Ill., are more than 60 drainage districts which have about \$2,800,000 invested in pumping plants. The annual cost of operating these plants, including fixed charges, is approximately \$650,000. Some of the plants are operated by electric motors, the oldest ones by steam power, and many of the newest installations by internal-combustion engines of the Diesel and semi-Diesel types. Because the pumps are not used continuously, but only when the river outside the district is high, most of these districts have considered it uneconomical to employ highly skilled engineers to operate the equipment.

Studies have been carried on for some years, looking to a determination of the conditions under which each kind of power is most economical, and of changes in equipment and methods of operation by which the cost of pump-

ing may be reduced to a minimum. Records of water pumped, of the frequency and duration of the periods of operation, and of the costs of operation were kept on 14 of the pumping plants. Owing to the variations in operating conditions, from year to year as well as between different plants, conclusions as to the limiting conditions for economical use of different kinds of power have not yet been reached. Recommendations made relative to operation, however, usually by changing the speed of the pumps have reduced the power consumption in eight plants by 10 to 33 per cent. A Second Progress Report on the Cost of Pumping for Drainage in the Upper Mississippi Valley During 1925 and a circular, Reduce Cost of Drainage Pumping by Regulating Speeds of Pumps, have been prepared for distribution to drainage engineers, drainage-district officials, and others interested in the subject.

FLOW OF WATER AROUND BENDS AND BRIDGE PIERS

Experiments supplementary to the earlier investigation of the effect of bends in the channel upon loss of head in open channels have been made during the year at the University of Iowa laboratory. Data have been collected also upon the effect of variations in direction and of rapid changes in speed of flow upon the registration of current meters.

A study of the obstruction to flow caused by bridge piers has been undertaken at the hydraulic laboratory of the University of Iowa. Some 360 experiments have been made on pier models with various shapes of noses and tails. Measured losses of head for various quantities of flow have been substituted in well-known pier formulas, and computations have been made of the empirical coefficients. The results indicate that the formulas are not entirely satisfactory, because the coefficient for each shape of pier is not constant for varying velocities of flow. The study of the increase in velocity of flow adjacent to the pier emphasizes the need for protection against scour and undermining.

ORGANIZATION AND DEVELOPMENT OF DRAINAGE DISTRICTS

The development of drainage districts to reclaim large tracts of swamp and overflowed land in the South has been disappointingly slow on the whole. Consequently a large amount of money

has been lost by the promoters, by buyers of the land, and by purchasers of the bonds issued by such enterprises. A report upon the agricultural and financial status of reclamation drainage districts in the Southern States has been prepared from the results of an investigation made in cooperation with the Bureau of Agricultural Economics.

CORN BORER CONTROL

The division of agricultural engineering has had charge of the mechanical equipment used by the Government in combating the European corn borer, and has made intensive studies of the design and use of such equipment for the work. In collaboration with entomologists of the department, tests have been made in badly infested fields of the efficiency of silage harvesters and stubble pulverizers in killing the borers, and of the performance of low-cutting corn binders. In cooperation with manufacturers of the machines, certain improvements made or suggested have been embodied in later models and have increased the effectiveness of the machines.

Studies have been made in cooperation with the entomologists to determine the temperature and period of exposure necessary to destroy the borers in the stalks, and the conditions influencing the effectiveness of burning. Various types of burners have been tested, and experiments have been made with burner carriages and with hoods for confining the flame in high winds. Simultaneously, pump-performance tests were made, and tests of friction losses in high-pressure hose of different diameters, length, discharge rates, and pump pressures; the fluid being the fuel oils used in the burners. Soil conditions in the spring prevent the use of very heavy machinery, thus increasing the difficulty of devising a practical burner.

A thorough study has been made of plows and plowing attachments for use in fighting the corn borer and of treatment of the fields before and after plowing to secure best results. Plows with wide bottoms were found most effective in covering the stalks, partly because of greater clearance and more room to adjust large coulters and jointers. Single-bottom plows gave somewhat better results than those with two or three bottoms. Disking or chopping standing stalks was found, in most cases, to be detrimental rather than helpful for clean plowing.

FARM STRUCTURES

Growers of sweet potatoes in tide-water Virginia and neighboring States ordinarily suffer considerable losses while the crops are in storage. Field studies were made, in cooperation with the Virginia Polytechnic Institute and the Virginia Truck Experiment Station at Norfolk, to determine the proper method of handling sweet-potato storage houses in order to hold the potatoes in good condition for marketing. The report of this investigation has been completed.

From studies made in Maine, a report on the requirements for, and construction of potato-storage houses has been prepared, the information to be applicable also in other northern potato-growing regions.

FARM MECHANICAL EQUIPMENT

COTTON-DUSTING MACHINERY

The experiments and tests of equipment for applying insecticides to cotton plants are being continued at Tallulah, La., in cooperation with the Bureau of Entomology as heretofore. Progress has been made in selecting and developing more effective machines and devices for this work, both horse-drawn equipment and for dusting the fields from airplanes. The work was interrupted for a time in 1927, owing to flooding of the experiment station from crevasses in the Mississippi levees.

COTTON-HARVESTING MACHINERY

One of the most laborious and costly operations in producing cotton has been that of harvesting the crop. Many times a considerable part of the crop has been lost for lack of labor to gather it. A great many mechanical devices for doing this work have been attempted by farm-machinery manufacturers, most of which have not been perfected to a practicable degree. During 1927, a study of equipment and methods, other than hand methods, being used or tried in northwestern Texas, was made by the division of agricultural engineering in cooperation with the State agricultural experiment station. Various kinds of strippers were examined, from simple homemade sleds to rather elaborate machines developed by large manufacturers, and the results obtained with the equipment under different conditions were noted and compared. The strippers gather the bolls and more or less trash with the seed cotton, which add to the

cost of ginning if not removed before being taken to the gin. Machinery for extracting the bolls and cleaning the cotton on the farm was studied.

Where the cotton plants grow large and the bolls ripen unevenly, stripping is not practicable, and for such conditions mechanical pickers with revolving spindles have been made. These are operated by tractors, and are expensive. They have not yet been developed to the point where their use is practicable under all conditions.

The results of this study have been prepared for publication by the Texas Agricultural Experiment Station.

COTTON-DRYING EQUIPMENT

Seed cotton as harvested many times is sufficiently damp to cause injury to the lint in ginning and to impair the planting and milling qualities of the seed. Present practice in cotton production is to have the crop ginned as rapidly as it is harvested without drying. For investigating the practicability of artificial drying, studies were made to determine the ordinary and the desirable moisture contents of seed cotton brought to gins, which indicated that 2½ to 5 per cent of the weight of the raw cotton should be removed before ginning.

Five different types of small units for artificial drying of seed cotton were constructed and tested, and a full-sized unit was constructed at Transylvania, La., having a capacity of 2 tons of seed cotton or 2 bales of lint cotton, per hour. Removal of moisture was secured by forcing heated air three times through a continuously moving layer of the cotton. The results of drying approximately 60 bales in the 1927 ginning season showed most of the dried cotton to have a value of one-half to 3 cents per pound over similar cotton ginned without drying. The cost of drying, under ordinary industrial conditions was indicated as about \$1 or less per bale.

Three public patents on the equipment and processes developed in this study have been applied for through the Department of Agriculture.

FERTILIZER DISTRIBUTORS

The economical use of fertilizers requires that they be distributed uniformly to the plants, and at a predetermined rate. It has been observed that present types of mechanical distributors, in general, give neither uniform distribution nor constant rates of delivery. In cooperation with the

Bureau of Chemistry and Soils, investigation has been made of the properties of the fertilizers and the characteristics of the distributors which affect the results. Study was made of the effect of such factors as the size of the particles of fertilizer, the shape of the particles, the amount and kind of conditioners used, the homogeneity of the material, and the humidity of the atmosphere, and also of the various mechanical principles and devices used for delivering the fertilizer from the hopper of the machine to the drills, of imperfections in the mechanical parts, of inaccuracies in adjustments, and of carelessness in operating the machines. The results are being prepared for publication for the benefit of manufacturers both of fertilizers and distributors, and of those who use the fertilizers in growing crops.

RESEARCH IN MECHANICAL FARM EQUIPMENT

The survey of the status of research in mechanical farm equipment begun about two years ago at the request of the National Association of Farm Equipment Manufacturers and the American Society of Agricultural Engineers, was completed. The final report, summarizing the present state of research in this field and containing suggestions for future procedure has been submitted for publication.

COMBINED HARVESTER-THRESHER STUDIES

Introduction of the combined harvester-thresher for harvesting wheat in the Great Plains States is causing marked changes in the harvesting methods there, and increasing use of those machines in other States apparently will cause like changes in more eastern regions. During the year there was published (Technical Bulletin No. 70) the result of the studies on the use of these machines made in Texas, Oklahoma, Kansas, Nebraska, and Montana, in cooperation with the Bureau of Agricultural Economics, the Bureau of Plant Industry, and the State agricultural experiment stations. Particular consideration was given by the agricultural engineers to the mechanical features of design and the manner of operation, for reducing costs of operation and repairs, and losses of grain in harvesting and threshing. Similar studies have subsequently been made in Illinois, Indiana, Pennsylvania, and Virginia, especially relative to the use of the harvester-thresher for soy beans and grain sorghums. A manuscript for a bulletin on the care and opera-

tion of the combine-harvester is in preparation.

TRANSPORTATION OF PERISHABLE PRODUCTS

Results of experiments made prior to 1927, in cooperation with the Bureau of Plant Industry, upon the insulation of refrigerator cars and the effect of moisture on thermal conductivity of the materials, and upon the value of body icing for various vegetables, have been prepared. Experiments have been made in heating and ventilating cars carrying winter shipments of products from the Pacific Northwest to eastern markets, and tests of various heaters for this purpose have been made. The effects of different methods of preparing and loading the cars have been studied, relative to uniformity of distribution of the heat and control of temperature. Valuable information has been obtained, but the tests will be continued in order to secure more certain results.

WAR-SURPLUS EXPLOSIVES FOR AGRICULTURAL USE

The final shipments of pyrotol, for agricultural use, were made in April, 1928. Pyrotol was the last of three explosives that have been available to the farmers since 1921, the others being picric acid and sodatol. Pyrotol was the name given to an explosive which was worked out experimentally in the endeavor to make use of a large quantity of smokeless powder turned over as surplus by the War Department. It was composed of smokeless powder (60 per cent), sodium nitrate (34 per cent), and a sensitizer (6 per cent). The materials were assembled, mixed, cartridgeed, and shipped under a contract awarded to E. I. du Pont de Nemours (Inc.). This work was done at three points—Gibbstown, N. J., Barksdale, Wis., and Du Pont, Wash. Carload shipments were made from these points on orders of the State agencies cooperating in this enterprise. As in the case of the other explosives, the cost to the farmer, at the plant, was only that of preparing and shipping and amounted to 6 cents per pound from the Gibbstown and Barksdale plants and 5.6 cents per pound from the Du Pont plant.

Pyrotol proved to be an excellent stumping explosive—perhaps the best of the three explosives distributed. Bulk for bulk, it was approximately equal in strength to 40 per cent dynamite. It was comparatively safe, and it did not stain or cause headache or other ill effects when handled. Table 23 shows by States the quantity of pyrotol distributed for agricultural use during the fiscal year 1928 and the totals of all war surplus explosives distributed for such use.

TABLE 23.—*Shipments of pyrotol, 1928, and of all explosives, 1922–1928, inclusive*

State	Pyrotol, fiscal year 1928	All explosives, fiscal years 1922–1928
	Pounds	Pounds
Alabama.....	153, 700	803, 900
Alaska.....	.....	5, 500
Arizona.....	.....	1, 300
Arkansas.....	16, 000	99, 400
California.....	74, 000	400, 400
Colorado.....	.....	150
Connecticut.....	.....	94, 400
Florida.....	.....	37, 000
Georgia.....	153, 300	436, 400
Hawaii.....	.....	1, 000
Idaho.....	250, 000	1, 758, 900
Illinois.....	23, 000	119, 200
Indiana.....	50, 000	252, 500
Iowa.....	265, 000	1, 568, 150
Kansas.....	.....	17, 800
Kentucky.....	.....	71, 150
Louisiana.....	20, 000	151, 900
Maryland.....	1, 000	14, 750
Michigan.....	584, 550	5, 813, 650
Minnesota.....	1, 336, 550	10, 568, 700
Mississippi.....	32, 000	200, 050
Missouri.....	116, 000	675, 800
Montana.....	100, 000	736, 100
Nebraska.....	86, 100	473, 650
New Jersey.....	.....	4, 200
New Mexico.....	.....	500
New York.....	.....	66, 450
North Carolina.....	577, 350	3, 690, 250
Ohio.....	32, 200	252, 200
Oklahoma.....	.....	400
Oregon.....	927, 500	5, 707, 950
Pennsylvania.....	32, 000	123, 600
South Carolina.....	210, 500	938, 700
South Dakota.....	81, 500	381, 500
Tennessee.....	13, 650	302, 750
Texas.....	52, 050	258, 300
Vermont.....	.....	5, 800
Virginia.....	106, 500	491, 350
Washington.....	1, 579, 900	10, 128, 800
West Virginia.....	36, 000	68, 250
Wisconsin.....	1, 200, 000	16, 968, 450
Experimental.....	.....	2, 400
Total.....	8, 110, 400	63, 693, 600

OFFICE OF THE SOLICITOR

No report published
for 1928

BUREAU OF SOILS

See

BUREAU OF CHEMISTRY AND SOILS

FEB 14 1929

EXPERIMENT STATION FILE

REPORT OF THE CHIEF OF THE WEATHER BUREAU
UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

Washington, D. C.,

September 5, 1928.

The Hon. W. M. Jardine,
Secretary of Agriculture.

Dear Mr. Secretary:

I have the honor to submit herewith the annual report of the Chief of the Weather Bureau for the year ended June 30, 1928.

Respectfully,



Chief of Bureau.

Two topics will be selected from the major activities of the bureau during the year ended June 30, 1928, for brief discussion in the abridged form of administrative report now in vogue, namely, (1) meteorology in aid of aviation, and (2) marine meteorology.

Meteorology in aid of Aviation.

Reference was made in the annual report for 1926 to the passage of the air commerce act, and we are now entering upon the third year of operations under the provisions of this act. It seems important to make of record the specific authority and

Release afternoon
November 30. 1928

provisions in this act governing meteorological work for aeronautics. Section 5 (e) makes an important amendment of the organic act of the Weather Bureau, and reads as follows:

(e) Section 3 of the Act entitled "An Act to increase the efficiency and reduce the expense of the Signal Corps of the Army, and to transfer the Weather Service to the Department of Agriculture," approved October 1, 1890, is amended by adding at the end thereof a new paragraph to read as follows:

"Within the limits of the appropriations which may be made for such purpose, it shall be the duty of the Chief of the Weather Bureau, under the direction of the Secretary of Agriculture, (a) to furnish such weather reports, forecasts, warnings, and advices as may be required to promote the safety and efficiency of air navigation in the United States and above the high seas, particularly upon civil airways designated by the Secretary of Commerce under authority of law as routes suitable for air commerce, and (b) for such purposes to observe, measure, and investigate atmospheric phenomena, and establish meteorological offices and stations."

The foregoing is the specific authority under which the Weather Bureau of the Department of Agriculture conducts all its activities in aid of aeronautics. However, in order that these activities may be thoroughly coordinated with the responsibilities and duties imposed upon the Department of Commerce in the same act, mention is made of an important portion of section 2 of said act, which reads as follows:

Sec. 2. PROMOTION OF AIR COMMERCE.-- It shall be the duty of the Secretary of Commerce to foster air commerce in accordance with the provisions of this Act, and for such purpose--

(a) * * * * *
(b) To make recommendations to the Secretary of Agriculture as to necessary meteorological service.
* * * * *

Funds enabling the Weather Bureau to function under these added responsibilities were first made available in deficiency appropriations, for 1926, and annually thereafter in regular appropri-

ations of the Department of Agriculture, always, however, based on specific recommendations by the Secretary of Commerce as to the amount of work necessary to meet the prospective establishment of airways and aeronautical work planned by the Department of Commerce. It is pleasing to state that the most friendly cooperation has characterized the joint operations of the representatives of the two departments engaged in performing their respective duties.

On the part of the Weather Bureau, the ultimate objective sought to be attained in every case, in connection with airways established by the Department of Commerce, is to assign and maintain on duty at every important airport one or more skilled meteorologists, whose duties require them to receive from the central organization of the Weather Bureau the fullest possible advices, reports, observations, etc., including forecasts and warnings, and to pass these on to pilots of airplanes at the time of, and in accordance with, the flight immediately in contemplation. In the performance of these duties by the Weather Bureau, hearty cooperation is necessary, not only on the part of pilots but of officials of the transport companies, also representatives of the municipalities and of the airports themselves, in order that housing facilities and accommodations may be provided for the meteorologists, to enable them to properly and efficiently perform their duties. Naturally, in the beginning facilities and accommodations of this character were sometimes

wholly wanting, or inadequate and uninviting, leading to discontent and dissatisfaction on the part of earnest-minded meteorologists. However, this condition is rapidly disappearing and provisions are now generally made that entirely facilitate the work of the Weather Bureau in this line.

The basis of advices and warnings to pilots is necessarily derived from the great network of meteorological stations that has been built up by the Weather Bureau throughout past years. In some cases these stations are rather widely distributed. Moreover, observations are made regularly only at 8 a.m. and 8 p. m. For the needs of aeronautics, more intensive and special stations are required, especially in certain regions. To make provisions for this, the policy of the Weather Bureau has been to establish what are called "ground stations" at frequent intervals all along the airway. These ground stations are very often supplementary landing fields, and are frequently manned by employees of the transport companies or others, whose meteorological duties are to report present weather conditions, including ceiling, visibility, etc., as far as practicable, either at fixed intervals between regular observations or whenever called for by the meteorologist at the main airport. This supplementary service, to be effective, requires immediately available channels of communication all along the airways, the maintenance of such channels of communication being in general the function of the Department of Commerce rather than of the Weather Bureau. In the absence of leased wires or other equally effective com-

munication along airways, it has sometimes been necessary to use commercial systems, which involve certain delays. However, with the development of airways and the perfection of the whole machinery of operation, the meteorological service is becoming more and more effective.

The expanse of the territory covered by airways in the continental area of the magnitude of the United States can hardly be realized by those not immediately responsible for the organization and establishment of the service, obviously at very considerable expense. Here, again, it is a pleasure to mention the very cordial cooperation that has been maintained with municipalities and organizations interested in aeronautics. During the past year, especially, one of the transport companies operating over California, undertook itself to organize certain intensive meteorological operations according to ideas of its own. In the course of time, however, this activity became absorbed in the general program of conduct of the Weather Bureau work in this field. The time is near at hand, however, as aviation becomes more extensive and traffic more congested when it will become necessary to supplement the two daily observations, at 12-hour intervals, by intermediate observations midway between. In fact, there is a growing demand for four observations from meteorological stations over the entire globe, instead of two as generally taken heretofore. The hours for these observations are quite likely to be advanced in the near future in the United States so as to occur at 1 and 7 a.m. and

1 and 7 p.m., instead of at 8 a.m. and 8 p.m. as in the past. Aerial navigation is chiefly the cause of this, but more frequent observations are of great value for many other purposes as well.

To meet modern demands in meteorology, it became necessary a few years ago to undertake the entire reorganization of the scheme for collecting, by telegraph, the meteorological reports from field stations. Passing over the extreme magnitude of an undertaking of this kind, and the difficulties involved, it is gratifying to report that a new and more flexible system is now in operation, which greatly facilitates the collecting of observations and placing them more promptly than heretofore in the hands of those entitled to use them. The new system, moreover, permits of the shifting of the hours of observations, as mentioned in the foregoing, which was not possible under the old method of collection.

These reorganizations of the work of the bureau have contributed very greatly to the better adjustment of the whole program of activities to the growing demands of the public, and of air navigation especially, and we confidently look forward to the rendering of an increasing amount of service of a highly efficient character.

Marine Meteorology

Progress in meteorology during recent years has been urged onward chiefly in order to meet the demands by aviation and the navigation of the air. In no other field has this been so

difficult and pressing as that of transoceanic air navigation. The dream of the meteorologists for many years has been the collection of systematic synoptic observations from ocean areas as well as from the elaborate network of continental stations each important nation has been able to set up. In past years, these synoptic observations by means of ship reports have been available only after, in some cases, many months, when the mail reports could reach their destination. The only use which it has been possible to make of such observations is to chart them with continental observations and prepare daily weather maps, possibly a year or more after the observations have been made. Now, however, to meet the needs of transoceanic navigation of the air, we must have observations immediately available by radio and otherwise. Such a service as yet only very imperfectly organized, but is the pressing need of meteorology at the present day. Plans are already far advanced for the making of long ocean flights by one or more huge airships, and in preliminary understandings the great maritime nations of the globe are agreed that the time is ripe for each nation to organize ocean meteorological observations by the selection of a certain number of ships of its own registry which shall uniformly make radio observations, at least twice a day, possibly four times daily, while on the high seas. Arrangements also provide for the collection of these ship reports at those coast stations best adapted to receive them, and to promptly interchange such observations, internationally, in con-

nection with observations at continental stations, thus placing at the disposal of all participating nations the complete network of simultaneous reports needed in the preparation of weather charts twice, or four times, daily.

Coincidental with the foregoing, especially in the United States, is the necessity of compiling and analyzing numerous observations received in the past by mail from ships at sea, in order that normal conditions shall be gradually established, and especially that conditions in remote regions from which few reports are received shall be brought up to date and the information made available to navigators, not only of the oceans but of the air. The necessity for the extension of the daily program of meteorological work to oceanic areas is more obvious when we consider that continental stations in the aggregate cover and represent approximately only one-fourth of the earth's surface, the remaining three-fourths being oceanic areas.

The highest efficiency and accuracy in formulating weather forecasts and warnings is only attainable when the meteorologist has before him a complete picture of the weather conditions over the whole surface of the globe, or at least over the whole surface of the Northern or the Southern Hemisphere.

Up to the present time the meteorologist has been limited in his knowledge of atmospheric conditions simply to the continental areas, and often only to a single continent.

The development of an international meteorological oceanic service along these lines is perhaps the most urgent technical problem concerning meteorology at the present time.



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